TATA ENERGY RESEARCH INSTITUTE
BANGALORE

COMPREHENSIVE ENERGY AUDIT REPORT

OF

INDIAN ALUMINIUM COMPANY LTD.
LOHARDAGA, BIHAR

Presented by

S. R. Govindaraj
S. Chandra Shekar

Tata Energy Research Institute
50/7, Palace Road, Bangalore Centre

H.O
Darbari Seth Block, India Habitat Centre
Lodi Road, New Delhi 110 003

MAY1997

TATA ENERGY RESEARCH INSTITUTE
BANGALORE

INDIAN ALUMINIUM COMPANY LTD.
LOHARDAGA
BIHAR - 835 302

"COMPREHENSIVE ENERGY AUDIT REPORT"

LIST OF APPENDICES

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

1.0 INTRODUCTION

This report presents the findings of the energy audit of Lohardaga Bauxite Mines, Indian Aluminium Co. Ltd. Bihar

The energy audit study was carried out during May'97 in the following areas to identify energy savings opportunities.

- Electrical System
- DG System
- Electric Drives
- Diesel Driven Machinery
- Kaolin Plant Hot Air Generator
- Lighting System
- Solar Heating System

The detailed study conducted has identified energy saving opportunities to the extent of 2,10,884 kWh of electricity and 1,01,115 ltrs of HSD fuel oil per year. This is tabulated as below.

Sl. No	Item	Qty. of Savings	Savings as a % of present consumption (1996)
1	Electricity (kWh)	2,10,884	25%
2	HSD Fuel oil (Ltrs)	1,01,115	15.3%

The total cost of energy savings recommended are estimated to be around Rs. 17.50 lakhs per year. The total energy saving potential in plant works out to be 23.3% of the total energy cost of Rs. 75.14 lakhs for the year 1996.

2.0 ENERGY CONSUMPTION PROFILE

The major sources of energy to the mines and plant for the year 1996 are given below:

Year	BSEB	Self Generation DG (kWh		HSD Consumption (Ltrs)		
	kWh	Own DG	Hired DG	Own DG	Hired DG	Mining Equipment
1996	474634	248932	120208	9125	46224	521558

The savings potential and payback period calculations are based on the present cost of power and fuel. Since the cost of power and fuel is constantly increasing, those recommendations, which may appear to be of a long gestation type will become attractive.

Sl. No	Proposal	Annual Energy Savings			Cost of implementation Rs.	Simple payback period Years
		Elec. kWh	HSD (ltrs)	Cost Rs.		
1	Electrical Systems	5511 (24 kVA-M.D)	-	54,186	24,000	< 0.5
2	DG System	-	17,620	1,60,000	1,50,000	0.93
3	Electrical Drives	69,135 (18 kVA M.D)	-	3,35,392	5,16,500	1.54
4	Diesel Driven Machinery	1,18,440	72,294	10,41,498	2,25,000	< 0.5
5	Kaolin Plant Hot air gen)	-	11,201	1,00,809	75,000	0.75
6	Lighting System	17,798	-	58,744	1,16,000	1.97
Total		**2,10,884 (42 kVA-M.D)**	**1,01,115**	**17,50,629**	**11,06,500**	**0.63**

3.0 ELECTRICAL SYSTEMS

The transformer loading is optimal and demand management has been good, scope exists to optimise the voltage levels in the plant for which the management should propose to install OLTC during new expansion plans.

A. Power Factor Management and Distribution Losses

The average pf of plant is 0.86 and above, however peak load pf of 0.79 has to be improved to 0.9. However, capacitor banks of 50 kVAr (in addition to the 40 kVAr procured already) should be installed at various distribution load feeders and re-distribution of the banks is expected to yield following results.

- Improve average pf to 0.92 and above (peak load pf to 0.9)
- Savings in distribution losses(5511 kWh) and demand(24 kVA)
- Releases kVA loading on DG set resulting in operation of one DG only.

Annual Cost of energy savings	=	Rs. 18,182/-
Annual cost of demand savings	=	Rs. 36,000
Cost of implementation	=	Rs. 15,000/-
Payback period	=	Less than ½ year

(Ref. Sec. 3.2-F)

B DG Set Optimum loading Schedule

The DG1 and DG2 systems are operated at low load factors. After implementation of proposal (A) above it is suggested to improve specific energy generation ratio to 3.4 kWh/ltrs by optimally adding loads to the operating DG set. The above proposal requires addition of changeover switches, isolators and periodic DG fuel pump calibration. It is observed that DG operating hours can be reduced by atleast 100 hrs/month by optimum loading of DG sets. (Ref. Sec. 3.3). The implementation of above proposal is expected to yield annual energy savings of Rs. 1.6 lakhs with an investment of Rs. 1.5 lakhs, expected payback in 1 year. For details regarding observations on improving specific energy generation ratio, Refer sec. 4.3.

C. Electricity Consumption in Quarters/Guest house

The electricity load of township feeder is high during morning and evening peak hours. Plant management has given incentives to encourage use of LPG instead of heaters. However connected load details indicate that peak load and demand situations can be avoided by executing control over the growth of electrical load. This necessitates operation of 2nd DG set during power failures. This can be avoided by effective monitoring of township loads, Thus achieving fuel savings. (Refer sec. 3.4 for details)

D. Metering Systems

It is suggested to install electronic energy meters for 3 nos. of DG sets and 5 load centres of various power supply distribution feeders of plant. Precise monitoring of power and energy parameters can facilitate better control. Plant management should install electronic indicating meters for control panels replacing present analogue meters. The above proposal is expected to cost Rs. 2.0 lakhs.

SUMMARY OF POTENTIAL SAVINGS

Sl. No	Proposal	Annual Savings		Cost of implementation Rs.	Simple payback period Years
		Energy (kWh)	Cost (Rs.)		
1	Reactive Compensation at load centres	5511 &(24kVA-M.D)	54,186	24,000	0.44
2*	Optimum loading of DG set and Improving SEGR		1,60,000	1,50,000	1 year
	Total	5511 24 (kVA-M.D)	2,14,186	1,74,000	

The computation of energy savings and costs saved have already been included in section 4.3.

4.0 D G SET

A. Load Management

The DG sets are poorly loaded. The spare capacities available on the DG sets are as follows:

DG Set Type	Spare Capacity in %
125 kVA	50
160 kVA	53.8

It is suggested that the loading of the electrical supply system is improved by better load management and planning.

The proposed load programme is tabulated as follows:

Item	Load kW		Rated
	BSEB 'ON'	BSEB 'OFF'	Capacity kW
125 kVA	-	-	100
160 kVA	-	113	128
BSEB Grid	113	-	-

Improvement in the load factor of the DG set will have a marked impact on fuel consumption. By improving the SEGR from 2.66(at present) to 3.40 by rationalising load management, the fuel consumption ratio per kWh generated could be reduced.

The following tabulation highlights the scheme:

Year	Present GMS/kWh Ratio	PCRA Norm @ 3.40 SEGR GMS/kWh	Potential Savings GMS/kWh	Potential Savings lit/kWh
1996	307	210	97	0.118

By improving load factor and SEGR, savings could be achieved as follows in HSD consumption

Annual Savings HSD		Cost of Implementation Rs.	Simple payback period Year
Energy Ltrs.	Cost Rs.		
17,620	1,60,000	1,50,000	1

5.0 ELECTRIC DRIVES

A. Energy Efficient Operation of Process Drives

The drives coupled to fans, mills and conveyors are operated on DG supply for more than 50% of production period. However DG is operated above 51.5% Hz and 450 volts most of the time without regulating the frequency as per load. Optimum operation of DG sets at 49-50 Hz for drives is expected to reduce kW loading of the DG set by 5-10%. This has been tried out and by analysing measured data, it is observed to yield the potential energy savings as under :

Refer Section 5.3 A,B,C for analysis of drives in Kaolin plant, pumping systems and mines.

Annual energy savings potential	=	25,800 kWh
Cost of energy savings @ Rs.3.5/kWh	=	Rs. 90,300/-
Cost of Implementation (for frequency alarm system to monitor DG frequency)	=	Rs.15,000/-
Simple payback period	=	Less than ½ year

B. Softstarter for Conveyor Motors

The operating pf of conveyor motors in mines is observed to be low due to load on motor being less than 50%. It is recommended to install pf controllers/soft starters for these conveyors for energy and demand savings.

The additional advantages are:

* Reduced mechanical wear and tear due to softstart feature.

* Reduced kVA load and instantaneous jerk load on DG minimised.

* Improved PF operation at all load cycles and motor heating at low load will be minimised. Implementation of this measure is expected to yield an annual saving potential of 19527 kWh and a demand saving of 18 kVA. (Refer Sec. 5.4).

Cost of energy savings	= Rs.46,527/-
Cost of Implementation	= Rs.2,00,500/-
Simple payback period	= 3-4 years

C. Optimum Sizing & Installation of Energy Efficient Motors

The installation of optimally sized energy efficient motors (EEM's) are recommended wherever motors are old, rewound several times and underloaded. It is proposed to replace 9 motors in Kaolin and mines area by EEM's which is expected to yield potential energy saving benefits. (Ref. Sec. 5.5)

Annual energy saving potential	= 23,808 kWh
Cost of annual energy savings	= Rs.78,565/-
Cost of implementation	= Rs.1,26,000/-
Payback period	= 1.60 years

D. Pulverising Plant - Process Modifications

It is proposed to install mechanised feed belt conveyor systems for transporting bauxite ore to the hammer mill. It is also suggested to install an AC motor with speed controller for feed rate management of bauxite to hammer mills-1, so that deployment of manpower could be avoided. This proposal is expected to relieve deployment of 2 personnel for manual work. Implementation of above measure is expected to save about Rs. 1.20 lakhs from manpower costs. The proposal with mechanical and electrical retrofits is expected to cost of Rs. 1.75 lakhs giving payback of 1.5 years. (Ref. Sec. 5.6)

E. General Recommendations

1. Star mode operation of tank agitator and screen motor should be considered. (Refer 5.2.C).

2. Use of flat belts and flat pulleys for compressors, apron feeder drive (crusher), fans in Kaolin and pulveriser plant should be considered to yield energy savings. (Refer 5.2.B (I).

3. Any unbalance in voltage above 1% should be examined for corrective action.

4. Use of low watt loss HRC fuses above 100 A rating should be considered.

Sl No	Proposal	Annual Energy Savings		Cost of implementation	Simple payback period
		kWh	Rs.	Rs.	Years
1.	Energy efficient operation of process drives	25,800	90,300	15,000	< 0.5
2.	Use of soft starter (electronic energy savers) for lightly loaded motors	19,527 18 kVA M.D	46,527	2,00,500	4.3
3.	Optimum sizing and installation of energy efficient motors	23,808	78,565	1,26,000	1.6
4.	Mechanisation of feed conveyor and feed system (Hammer mill) in pulverising plant	-	1,20,000	1,75,000	1.5
	TOTAL	**69,135 (18 kVA MD)**	**3,35,392**	**5,16,500**	**1.54**

6.0 DIESEL DRIVEN MACHINERY

A. Cater Pillar Engines at Crushing Plant

A study was conducted on both the engines at the crushing and screening plant.

It was observed that the radiator air velocity was low for the 180 HP engine.

Both the engines are provided with power take off shafts which can drive through belt drives a 25 kW alternator from the 295 HP engine and a 25 kW alternator from the 185HP engine. The electric power generation from the power take-off shafts will render the crushing and screening plant in totality self sufficient as regards electric power requirements for conveyors, screens and feeder.

Annual Energy Savings			Cost of implementation Rs.	Simple payback period Years
Elec. kWh	HSD Ltrs.	Cost Rs.		
1,18,440	-	3,90,852	2,25,000	0.58

B Dumper Fuel Consumption

The dumpers were studied for fuel consumption. The fuel consumption figure derived is much lower than the computed figures noted in the log book.

An average all round saving of 12% is envisaged for all the dumper, loaders and ripper dozers.

Annual Energy Savings		Cost of implementation Rs.	Simple payback period Years
HSD Ltrs.	Cost Rs.		
72294	650646	Negligible	Immediate

7.0 KAOLIN PLANT - HOT AIR GENERATOR

A. The outside shell of the hot air generator should be insulated. The insulation materials are all available at the plant site already supplied by the equipment supplier. Proper insulation of the shell will achieve HSD fuel oil savings.

B. The top portion of the swirl dryer is not insulated. The same should be insulated at the earliest, since all insulation materials are available at site.

C. There is considerable heat loss from openings between flanges and joint plates in the burner side end of the hot air generator. Losses are also present at the joints at the opposite end. Rectification of these leaks will save HSD fuel oil.

D. A fair amount of heat is being taken away by the hot exhaust gas through the chimney. This gas could be used for preheating the combustion air being supplied to the burner. By preheating the combustion air, HSD fuel oil could be saved.

Sl. No.	Proposal	Annual Savings HSD		Cost of Implementation	Simple payback period
		l/yr	Rs./yr	Rs.	Years
1.	Rectifying heat loss from uninsulated shell	8190	73710	Nil	Immediate
2.	Rectifying heat loss from leakages in shell	120	1080	Nil	Immediate
3.	Recovery of waste heat in exhaust gas to preheat combustion air	2891	26019	75,000	2.88
TOTAL		**11201**	**1,00,809**	**75,000**	-

8.0 LIGHTING SYSTEM

A. Replacement of 12W HPMV lamps by 70W HPSV Lamps

The street lighting in township has 32 nos. of 125W HPMV fittings, which could be replaced with 70W HPSV fittings in a phased manner. This measure is expected to yield energy savings as given below with additional benefits of improved visibility and spread of the lignt.

Annual energy savings	=	8250 kWh
Annual Cost of energy savings	=	Rs. 27,225/-
Annual cost of Investment	=	Rs. 80,000/-
Simple payback period	=	2.9 years

B Replacement of Incandescent Lamps with Fluorescent Lamps

The incandescent lamps of 100W and 200W which are used extensively in the plant should be replaced by 40W fluorescent tube lights. The details of replacement option for production and township areas are given in Appendix - 8/5.

Annual energy savings	=	6204 kWh
Annual Cost of energy savings	=	Rs. 20,470/-
Annual cost of Investment	=	Rs. 6,000/-
Simple payback period	=	0.3 years

C Replacement of Incandescent Lamps by energy efficient compact fluorescent lamps (CFL)

The existing 100W incandescent lamps at corridors, entrance of offices and guest house should be replaced by CFL's of 15W or 25W. The techno-economic details of installing 6 nos. of CFL's are given in Appendix-8/6.

Annual energy savings	=	1902 kWh
Annual Cost of energy savings	=	Rs. 6,276/-
Annual cost of Investment	=	Rs. 2,600/-
Simple payback period	=	< ½ year

D Replacement of Incandescent and HPMV Lamps by HPSV Lamps

The incandescent lamps and HPMV lamps installed for outdoor building lighting should be replaced by 70W HPSV lamps.

This measure is expected to yield annual energy savings as mentioned below(Ref. Appendix - 8/7).

Annual energy savings	=	2812 kWh
Annual Cost of energy savings	=	Rs. 9,280/-
Annual cost of Investment	=	Rs. 27,500/-
Simple payback period	=	3.0 years

E. Use of Timer for Effective Control and Switching for sports club

A timer should be installed for switching 'off; the 3 nos. of 70W HPSV lamps in the club house. (Ref. Section 8.2 (F) for details)

Annual energy savings	=	536 kWh
Annual Cost of energy savings	=	Rs. 1,769/-
Annual cost of Investment	=	Rs. 2,500/-
Simple payback period	=	1.4 years

F. Installation of Solar Photo-voltaic System for Street Lighting

It is economical to install solar photo-voltaic system for street lighting, where power supply has to be drawn to considerable lengths. This system is also proposed for emergency lighting system at considering safety and security aspects. The system is expected to cost about Rs. 3.0 lakhs for 15 nos. of stand alone solar street lighting systems. . The details are presented in section 8.3 and addresses are given in chapter Retrofits."

Sl. No	Proposal	Annual Savings		Cost of implementation Rs.	Simple payback period Years
		Energy(kWh)	Cost (Rs.)		
1	Replacement of 12W HPMV lamps by 70W HPSV Lamps	8250	27225	80000	2.9
2	Replacement of incandescent lamps with 40W fluorescent lamps	6200	20470	6000	0.3
3	Replacement of incandescent and HPMV lamps by HPSV lamps	2812	9280	27500	3.0
4	Use of timer for effective control and switching for sports club	536	1769	2500	1.4
	Total	17798	58744	116,000	-

MAIN REPORT

INDIAN ALUMINIUM COMPANY LTD.
LOHARDAGA
BIHAR

COMPREHENSIVE ENERGY AUDIT REPORT

1.0 INTRODUCTION

This report presents the findings of the energy audit of Lohardaga Bauxite Mines, Indian Aluminium Co. Ltd. Bihar.

The Mines and Processing plants specialise in the mining, crushing, screening, pulverising and transportation of Bauxite Ore and Kaolin. Besides supplying Bauxite ore to the smelter of Indal, it also markets directly to end users.

The Energy Audit study was carried out during May, 1997 in the following areas to identify energy savings opportunities.

- Electrical System
- DG System
- Electric Drives
- Diesel Driven Machinery
- Kaolin Plant Hot Air Generator
- Lighting System
- Solar Heating System

During the study, every attempt was made to understand the operational features and working of the mines and plant in the proper perspective for the purpose of analysis. The various operations were observed, relevant data collected and measurements taken wherever necessary using portable instruments. There was constant interaction with the plant personnel who gave full support and co-operation to the study team. The report presents the analysis, findings and recommendations for achieving energy savings with required back up in techno-economic details and simple payback calculations.

2.0 ENERGY CONSUMPTION PROFILE

The major sources of energy to the mines and plant are tabulated below for the year 1996.

Month	Total power consn. kWh	Source of Power				
		B.S.E.B	Own Generation		Hired D.G.Set	
		kWh	kWh	HSD Consn.	kWh	HSD Consn.
Jan 96	69816	59650	10166	3705	-	-
Feb 96	50273	37786	12487	4910	-	-
Mar 96	55631	29066	26565	10760	-	-
Apr 96	53187	39506	13681	5365	-	-
May 96	58171	34223	20448	7950	3500	N.A.
Jun 96	64246	38241	19812	6750	6193	2240
Jul 96	91013	51350	33800	11970	5863	2089
Aug 96	87424	44103	36313	12920	7008	3090
Sep 96	71919	22063	33539	12325	16317	7160
Oct 96	94980	43967	21573	8925	29440	11380
Nov 96	69726	42358	12191	4390	15177	5775
Dec 96	92144	32321	8357	3155	36710	14490

The department wise - energy supply and consumption details are given in Appendix -2/1.

The HSD consumption profile for the year 1996 is given in Appendix 2/2.

Department-wise production figures were not available in order to calculate energy consumption vs. production output ratio.

3.0 ELECTRICAL SYSTEM

This section covers the study of electrical power receiving and distribution systems. It includes electrical substation, transformer load management, pf compensation, distribution losses, DG load management etc.,

3.1 FACILITY DESCRIPTION

The main source of electricity is from BSEB received at 11kV through overhead lines running over a length of 11 kms. Alternate or standby source of electricity is from 1X125, 1 X 160 kVA DG sets and one 180kVA DG set hired for mines. The plant has the following electrical system load details.

Contract demand	=	350 kVA
Maximum demand during Mar'97	=	276 kVA
Average demand	=	250 kVA
Average pf	=	0.92 and above (lowest 0.867 Mar'97)
Energy charges/kWh (ED)	=	Rs.1.78 + 0.26(FEC) + 0.15
Demand charges/kVA	=	Rs.125
Annual energy consumption (1996)	=	8,50,000 kWh (approx.) (Including DG energy)
- BSEB	=	4,74,000 kWh (55%)
- DG (self gen)	=	3,76,000 kWh (45%)

The plant is having 2 nos. of distribution transformers of capacity 300 kVA & 200 kVA each feeding to the LT panels. The network details are presented in the single line diagram (refer Appendix - 3/1). The name plate details of the transformers and alternators are presented in Appendix - 3/2.

3.1.1 Distribution Substation

The power supply is received through LT cables from outdoor switchyard. The 300 kVA transformers are provided with ACB of 415V, 800A, 36MVA capacity, whereas the 200 kVA transformer is having 400 A switch & OCB in line. Both the transformers are provided with off load tap changing switch. The LT outgoing feeders are running either to DBS or directly to higher HP Motors. The change over of DG supply is carried out at PMCC Panel using ACB's with interlocks.

3.1.2 Capacitor Banks

Capacitor banks of 120 kVAr rating are directly provided on the LT bus of both the transformers. These are located at LT room and are switched through isolators and fuse switches (the capacitor banks are switched manually).

3.1.3 Distribution System

The main in-comer from the transformer to the PCC is through 3½ x 150mm^2 PVC aluminium cables. Similar arrangements are also done for incoming cables from DG sets, and for the feeder supplying load centres. All other load feeders have cables of sizes upto 35 sq mm. The cables outgoing to some motors are extended upto a length of 300 meters, The township load is supplied through a voltage regulator (presently operated in manual mode) for optimum voltage of distribution.

3.2 OBSERVATION, ANALYSIS AND FINDINGS

A. General

Electricity distribution is from BSEB and captive DG sets. The reliability and power supply quality for the plant is affected, since the grid supply from BSEB is not stable. BSEB supply is drawn from overhead line over 15 kms distance and breakdowns are mainly due to the old insulators, conductor jumps/joints, snapping of lines etc. The standby DG sets are used during power shutdowns which supply for over 50% of time in a month. The details of monthly BSEB interruptions and record of monthly DG set operations are given in Appendix - 3/3. The plant management has devised means of extending DG power as and when additional loads are added for flexibility, however this has resulted in haphazard changeover system.

B. Contract demand Management

The plant has obtained a sanction of 350 kVA maximum demand at 11 kV feeder. The transformer capacity provided for receiving the demand is 500 kVA i.e. 1 X 300 kVA and 1 X 200 kVA, and this has been proposed as 150% of contracted demand according to BSEB rules.

Details of energy consumption data and maximum demand recorded for 1996-97 are given in Appendix - 3/4. The recorded minimum is 183 kVA and maximum being 276 kVA (Mar'97). However, the maximum demand recorded is observed to be high due to low instantaneous pf (as low as 0.79) during peak load and fluctuating voltage level. Discussion regarding the above are dealt in subsequent chapters.

The plant connected load data and area-wise measured data of the plant are given in Appendix - 3/5.

C Transformer Load Management

The 2 Nos. of transformers are situated at load centres and supply feeder is through weasel conductor from BSEB. LT distribution scheme is evolved with alternate supply arrangement from DG sets.

Transformer Ref.	Feeding To	Maximum Load
T1 - 300 kVA	Office, power house, kaolin plant, township loads	160 kVA
T2 - 200 kVA	Rollover 1&2, crusher 1&2, Ropeway	160 kVA

The transformer loading is optimal and pf compensation provided on incoming LT feeder has minimised ampere loading of transformer and hence losses are minimum. The following general points are highlighted

The 200 kVA transformer offload tap settings are reported to be kept at No.1. This was however not established since markings are missing. Shutdown should be taken and adjusted, so that highest voltage is available on secondary to overcome the problems of low voltage. The 300 kVA transformer is set at tap-1 which is observed to be optimal for the voltage supply from BSEB.

ii. The oil filtration of transformers should be regularly carried out (once in a year) and temperature of windings should be noted once in a day.

iii. Seasonal adjustment of offload taps of transformer should be considered depending on grid voltage levels to obtain 400 volts & above on secondary.

D. Voltage Levels and PF Management

The incoming power system load details were measured for a typical working day using portable power analyser. The details are given in Appendix - 3/6:

The incoming voltage is varying between 386 to 444 volts. As reported the observed variations are the same during any part of the year. The low voltage levels of 9.0 kV are reported due to long length of incoming 11 kV feeder and low grid voltage supply received at 33kV station. However voltage levels are reported to be satisfactory during night periods and this is as high as 450 volts on secondary. The DG power distribution system being extended for 50% of the time, the voltage levels are observed to be as high as 450 -460V, however load end voltages are at 430 - 440 volts.

The offload tap settings of both the transformers are kept at No.5, so as to receive 105% of incoming system voltage and this is maximum possible. The only alternative to have optimum voltage levels on secondary is by installing automatic on load tap changers or installing line boosters.

E. OLTC for New Project Expansion Plans

The incoming voltage fluctuations being severe (through out the year). Plant management must consider installing "on load tap-changers" for transformers that are proposed for procurement during "KAOLIN" expansion project. The above is expected to cost about Rs. 2.0 lakhs more for 1000 kVA transformer, however, such a retrofit is expected to improve overall system efficiency by 1-2% of energy consumption with large system benefits like improved pf operation, reduction in kVA load and minimum distribution losses. The township loads of 50-60kW have been installed with manual voltage regulator giving an output of 400 volts with an input range of 300 -420 volts and this is a good measure.

F. Power Factor Management and Distribution Losses

i. General

The average PF of BSEB incomer has been maintained above 0.85 lag. Plant Management has installed 120 kVAr of capacitor banks on LT bus section of both 300 kVA & 200 kVA transformers. There is a proposal to install 40 kVAr capacitor banks on "KAOLIN" plant main LT incomer situated 120 meters from main LT room.

The recorded average pf of 11 kV incomer are given below

Average	PF	M.D Recorded	Period
Highest	0.964	222	Jul'96
Lowest	0.867	276	Mar'97

It is observed that average pf recorded was the lowest figure of 0.867 and demand recorded the highest at 276 kVA. The details of load measurements carried out on 300 kVA transformer (Appendix-3/7) indicate that the instantaneous pf recorded is as low as 0.79 lag. This peak load pf needs to be corrected by which the average pf of installation can be maintained above 0.92.

ii. Redistribution of Capacitor banks

Details of load measurements on feeders indicated that the pf is as low as 0.5 lag and this needs to be improved by redistribution of capacitor banks from main incomer bus to various load feeder bus sections. Redistribution of capacitor banks on load end feeders which are having more lengths, by retaining part of the kVAr's on main incomer is expected to minimise distribution losses. Details of the energy savings are given in subsequent paragraphs. The additional capacitor banks to be procured for installation at various feeders works out to about 50 kVAr.

S. No	Load Feeder Details	Existing kVAr	Proposed kVAr	Remarks
1	300 kVA transformer LT bus	60	60	
2	Kaolin plant main LT bus	40 (procured already)	20	Shift 20 kVAr
3	200 kVA transformer LT bus	60	40	Shift 20 kVAr
4	Ropeway	-	10	To be procured
5	Pulveriser - 1 Incomer	-	10	To be procured
6	P.V Main Panels	-	10	To be procured
7	Bauxite Screening Crusher-1 Crusher - 2	-	10 20	To be procured Install from 2 above
8	Township feeder panel	-	20	Install from 3 above
9	Borewell Pump House	-	10	To be procured

Note: While installing the capacitor banks, it may be ensured that the capacitor banks are connected at the downstream of any switch/isolator so that benefits of reduced ampere loading is most optimal.

The above proposal is expected to minimise kVA load on DG set also, by improving pf of load upto 0.9 lag which is measured to be 0.5 - 0.7 lag. The details of these measurements and techno-economics are given in Appendix - 3/8.

iii. Choice of voltage of capacitor banks & Installation of additional capacitor banks.

The capacitor banks are having a voltage rating of 440 volts and the observed voltage levels 400-420 volts. The output of capacitors banks in kVAr is proportional to (volts applied/Rated volts)^2. Hence, the existing 120 kVAr banks will not be delivering 100% output instead of 90% i.e 106 kVAr output. However monitoring of individual capacitor bank amperes should be followed once in a month and any abnormal derating in amperage drawn due to leakages, breakdown etc. should be attended and faulty units should be replaced. The average monthly pf of incomer is as low as 0.86 and peak load pf being low, it is recommended to install another 50 kVAr capacitor banks in line so that with the eventual failure of certain banks, and derated output conditions, MD can be controlled within limits.

This proposal is expected to cost Rs.15,000/-. Considering saving in MD by atleast 50% of estimated kVA savings i.e 24 kVA, the saving from for demand charges will be Rs.36,000/-. The payback on such investments will be less than 1 year. The energy savings by way of savings in distribution losses account for about 5510 kWh(Rs.18,182).

3.3 ENERGY EFFICIENCY IN DG POWER DISTRIBUTION SYSTEM

The DG power distribution system comprises of the following pattern, with changeover system at various production centres of plant

DG #	Load Feeders	Remarks
DG-# 1 125 kVA	Kaolin plant, Township & Offices	Alternate, feeding to crushers/Ropeway, via. 1.35 kVA dig conductor
DG-# 1 160 kVA	Kaolin plant, Township & Offices	O/H line; During lean period, one DG can cater to complete plant loads
DG-# 1 180 kVA	Pulveriser 1 & 2, crushers, Ropeway	During power failure & DG breakdown Pulveriser 1 & 2 are not having any alternate arrangement

The single line diagram indicates that either DG1 or DG2 can extend power supply to Kaolin and Township loads and power supply could be extended to mines (crushers & ropeway) only in the event of breakdown of hired 180 kVA DG set. In the above circumstances Pulveriser section will not have alternate supply leading to production loss.

The loading operation of DG sets for a typical day has been analysed and observations details are given in chapter No. 4.0. However, the kVA loading of each alternator has been on the higher side, since capacitor banks are not included in the load side of feeder bus. Measurements of power analyser are given below.

TIME	MEASURED 3- Ph. PARAMETERS						% LOADING
	Volts	Amps	Pf.				
D.G--2	V	A	Cosϕ	kVA	kW	kVAr	
11	446	81.4	0.65	70.6	45.8	53.8	44.1
	447	87.9	0.69	75.7	51.9	55.1	47.3
	447	89.4	0.68	83.6	53.0	50.0	52.3
	447	92.3	0.58	71.3	41.4	58.1	44.6
	447	110.0	0.68	85.2	58.1	62.0	53.3
11.30	447	113.0	0.72	87.7	62.8	61.3	54.8
	447	123.0	0.71	67.3	45.2	67.3	42.1
	445	119.0	0.75	91.4	68.2	91.4	60.8
	445	87.0	0.66	67.4	44.5	50.0	42.1
12	445	90.00	0.73	69.7	50.5	48.4	43.6
D.G--1							
12.30	447	99.0	0.68	76.8	52.3	56.0	48.0
	447	93.0	0.69	72.0	49.9	52.0	45.0
13.00	445	70.0	0.72	54.0	38.5	38.0	33.8
13.10	444	70.0	0.69	55.0	37.5	40.0	34.4
13.20	444	99.0	0.68	77.0	53.0	56.0	48.1
14.40	448	91.0	0.70	72.4	50.4	51.9	45.3

Summary of loading data are given below:

DG Ref	PF		Load kW		Load kVA	
	Low	High	Low	High	Low	High
DG-1	0.68 -	0.72	38.5 -	52.3	54 -	77
DG-2	0.65 -	0.75	41.4 -	62.8	67.3 -	91.4

From the above, the kVA loading is high since pf of load is as low as 0.65 lag. This is due to pf capacitor banks installed at BSEB I/C bus which does not get switched 'ON' after changing over to DG bus during power failure.

A review of loading pattern of DG1 and DG2 with load pf improved to 0.90 lag shows that kVA loading on DG1, or DG2 can be reduced to a great extent. It is observed that operating 2nd DG set during peak production hours i.e is 8.00 - 6.00 p.m does not arise, since it is observed that DG2 can share the total (Refer Appendix - 3/9 for loading of DG1 and DG2)

Energy savings by optimally loading DG-2 and having DG-1 as standby are worked out. Reference to Appendix - 3/3 shows that power failure hours averages to 210 hrs/month, whereas operation of DG1 and DG2 account for 366 hrs/month for 1996. Details are given below for Jan-Dec, 1996

	BSEB power failure hrs	# of interruptions	DG-1 hrs	DG-2 hrs	DG-3 (hired)
Total	2526	889	2013	2381	708 for 3 months
Monthly Avg.	210	74	167	198	236

From the above, it is observed that DG1 and DG2 are operated along with hired DG set load at a low load factor. During power failure the operation of DG-2 should be carried out at higher load factor and DG-1 as standby or utilised for operation during lean periods. Further to pf improvement of loads given in sec. 3.2(E), even with 50 hrs operation of DG-1 per month (in addition to operating DG-2 for most parts of power failure period) it is possible to achieve fuel savings for more than 100 hrs operating per month.

Details of improving specific energy generation ratio for DG set 1 & 2 dealt in section 4.3.

By improving load factor of DG2 and operating at max. loaded condition, it is possible to achieve fuel savings of Rs. 1.60 lakhs per annum. (Ref. Section 4.3).

The above discussion also holds good considering that operation of DG1 for 100 hrs/month could be saved resulting in fuel savings.

Assuming fuel consumption by DG1 to be 15 ltrs/h annual energy savings will be: = (15l X 100h X 12 months) X Rs.9

= Rs. 1.6 lakhs

The cost of implementation works out to Rs. 1.50 lakh for modifications in changeover switches, fuel pump calibration, cables, isolators etc. The above proposal is expected to payback in one year period.

3.4 CONSUMPTION OF ELECTRICITY BY RESIDENTIAL QUARTERS/ GUEST HOUSE

The electricity consumption by township has been steadily increasing and due to power failure, there has been a necessity to operate 1 X 160 kVA DG set. Many times during morning (6 - 9 a.m) peak period and evening peak hours (6-9 pm), necessity of operating 2 DG sets for plant and Township has been observed. This is due to addition of geysers and heaters at the residential quarters. However, plant management has initiated an incentive measure to encourage use of LPG instead of electricity for cooking. This is appreciable, however as per records almost all the 136 quarters have 1.5 kW immersion rods or 1.5 kW heaters for cooking (including guest house).

The MC, C and D type quarters (including temporary block) are not originally proposed with heating loads. The usage of heaters for cooking has contributed to extra load on BSEB or DG set. Plant management should review the system before initiating programme of adding further loads during power failure. Details of quarters and heater loads are given in Appendix-3/10. (Refer Appendix 8/1 for list of connected loads).

It is proposed to install solar cookers for the guest house and engineers mess (as an immediate measure) and further plant management may propose the same for residents of township. Address of manufacturer's of solar cookers are given in chapter "Retrofits'. IREDA offers incentives for such procurement.

3.5 PLANT METERING SYSTEMS

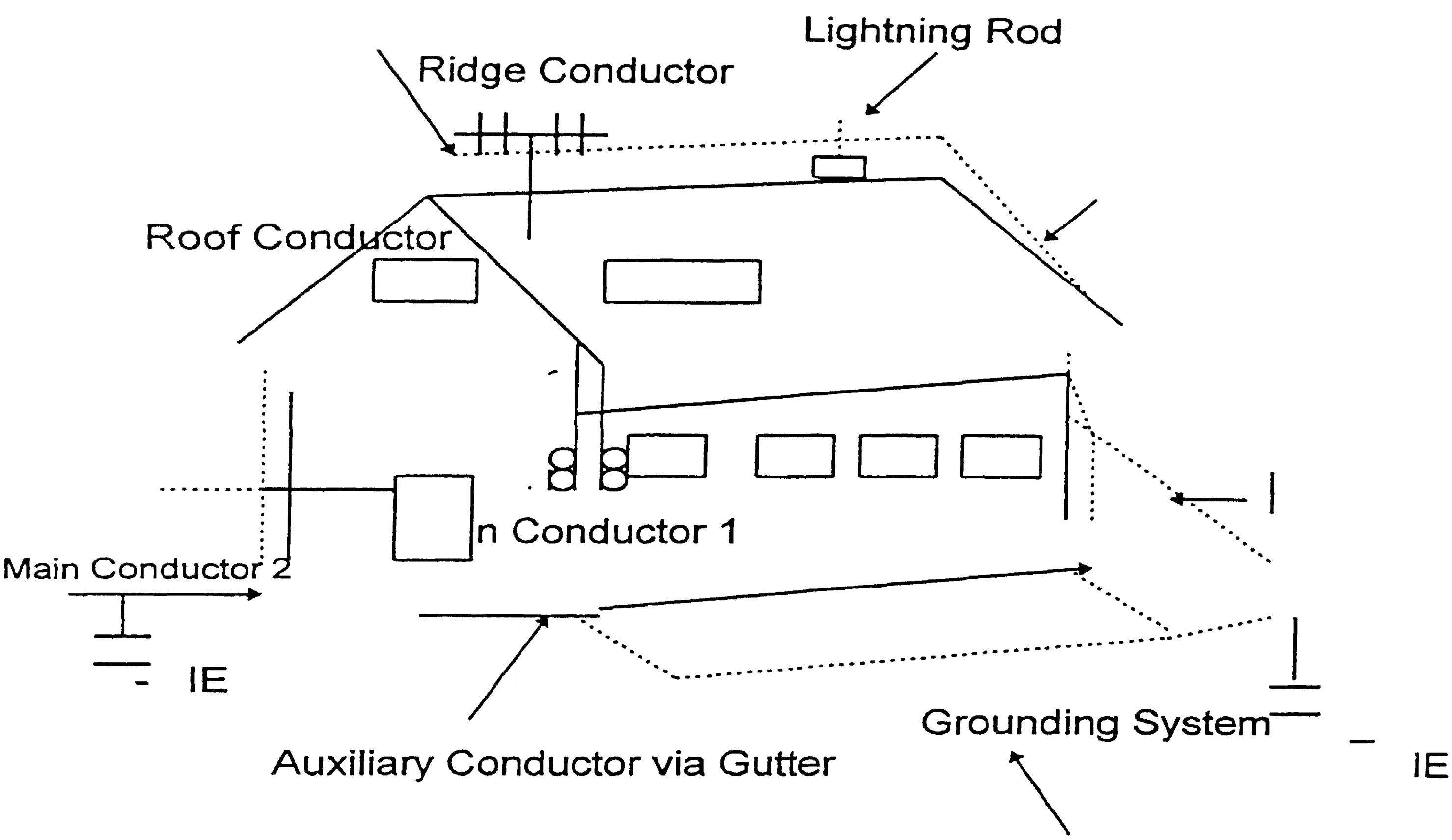
The plant has electronic energy meter at the BSEB incomer and incomer/ DG control panels have analogue/electro-mechanical meters for load parameter and energy. The instrumentation / metering system need to be improved further, which enables the plant management to effectively monitor the load parameters and energy consumption/generation data. Any expenditure towards metering systems could result in effective monitoring and energy management practices.

Electronic energy meters are available today costing about Rs.3,000/- which will effectively record and transmit information to a centralised computer. The above system should be incorporated for main DG and load feeders including lighting. A check on past consumption record is a must so that quick analysis of past consumption could be predicted. Such a system is possible to be incorporated with an investment of 1.5 to 2.0 lakhs. The investment being large, plant management has to look into the awareness and energy management benefits thereof which have been reported to an extent of 1-2% of total consumption in various plants. Addresses of suppliers are furnished in chapter "Retrofits".

3.6 LIGHTNING PROTECTION SYSTEMS

The following information is given on lightning protection systems as desired by plant management. Danger of fire, damage of roofs, masonry etc. are likely to occur if lightning strikes an unprotected building. In view of some past occurrences such as damages to some parts of the mine shed, electric shock to the personnel etc. in INDAL plant lightning protection is recommended for the shed as detailed below

Lighting protection system consist of lightning protector and grounding installation.



LIGHTNING PROTECTORS

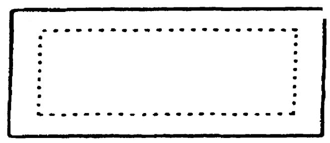
These are copper or steel strips laid on the roof of the building. The configuration used will depend upon the size and shape of the roof. No point in the roof may be more than 10 m from the nearest protector. Projection such as antenna can be used as protection if they are made of metal. Otherwise, they are to be fitted with lightning rods.

Case Study

Dimensions of building/shed

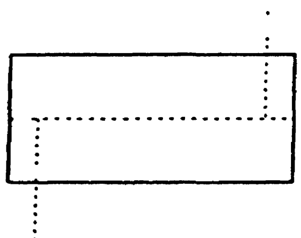
Length upto 20 m, Width : upto 12 m

Flat roof shed
(Buildings)



Ridge to caping distance $\leq$ 1m

Gable roof



Ridge to caping distance $\geq$ 1 m

LIGHTNING CONDUCTORS

The connecting elements between lightning protection and grounding installation are termed lightning conductors.

Recommended Material	Dimension
Steel rod, Copper rod	ϕ 8 mm
Aluminium rod	ϕ 10 mm
Aluminium strip or steel strip	ϕ 20 mm

The main conductors can be as given in the table above. Auxiliary conductor can be metal parts of a building e.g. drain pipes. For ease of measurement, the conductor must be connected to the grounding installation via separating terminal. A brief enumeration is given in Appendix - 3/11. Grounding installation must provide a reliable permanent contact between lightning protection system and ground.

Material	Dimension
Steep rod	ϕ 10 mm
Copper rod	ϕ 8 mm
Steel strip	30 mm - 3.5.
Copper strip	20 mm - 2.5

3.7 RECOMMENDATIONS

A. Power Factor Management and Distribution Losses

The average pf of plant is 0.86 and above, however peak load pf of 0.79 has to be improved to 0.9. Additional 40 kVAr capacitor banks (in addition to the 40 kVAr procured already) should be installed at various distribution load feeders and re-distribution of the banks is expected to yield following results

- Improve average pf to 0.92 and above (peak load pf to 0.9)
- Savings in distribution losses(5511 kWh) and demand(24 kVA)
- Releases kVA loading on DG set resulting in operation of one DG only.

Annual Cost of energy savings	=	Rs. 18,182/-
Annual cost of demand savings	=	Rs. 36,000
Cost of implementation	=	Rs. 15,000/-
Payback period	=	Less than ½ year

B DG Set Optimum loading Schedule

The DG1 and DG2 systems are operated at low load factors. After implementation of proposal (A) above it is suggested to improve specific energy generation ratio to 3.4 kWh/ltrs by optimally adding loads to the operating DG set. The above proposal requires addition of changeover switches, isolators and periodic DG fuel pump calibration. (Refer sec. 4.3 for other detail).

The implementation of above proposal is expected to yield annual energy savings of Rs. 1.6 lakhs with an investment of Rs. 1.5 lakhs, expected payback in 1 year. For details regarding observations on improving specific energy generation ratio, (Refer sec. 4.3)

C. Electricity Consumption in Quarters/Guest house

The electricity load of township feeder is high during morning and evening peak hours. Plant management has given incentives to encourage use of LPG instead of heaters. However connected load details indicate that peak load and demand situations can be avoided by expecting control over the growth of electrical load. This facilitates operation of addition (2nd DG set) during power failures which can be avoided for conservation of fuel. (Refer sec. 3.4 for details)

D. Metering Systems

It is suggested to install electronic energy meters for 3 nos. of DG and 5 load centres of various power supply distribution feeders of plant. Precise monitoring of power and energy parameters can facilitate better control action. Plant management should install electronic indicating meters for control panels replacing analogue meters. The above proposal is expected to cost Rs. 2.0 lakhs.

3.8 SUMMARY OF POTENTIAL SAVINGS

Sl. No	Proposal	Annual Savings		Cost of implementation Rs.	Simple payback period Years
		Energy (kWh)	Cost (Rs.)		
1	Reactive Compensation at load centres	5511 &(24kVA-M.D)	54,186	24,000	0.44
2*	Optimum loading of DG set and Improving SEGR	-	1,60,000	1,50,000	1 year
	Total	5511 24 (kVA-M.D)	2,14,186	1,74,000	

* The computation of energy savings and costs saved have already been included in section 4.3.

4.0 D.G SETS

4.1 FACILITY DESCRIPTION

The Mines have 2 nos. of DG sets of capacity 125 kVA and 160 kVA. There is also a hired 180 kVA DG set at the pulverising plant located 1.5 kms from the 125 kVA and 160 kWA DG sets. Studies were conducted only on the 125 kVA and 160 kVA DG sets since the hired 180 kVA was to be returned shortly. The name plate details of the two DG sets alternators are given in Appendix - 4/1.

The objectives of installing these two DG sets is to create captive power generating capacity to supplement the BSEB grid supply which is not available during load shedding and power shut down. One DG set is operated at a time and provision is available for loading any DG set, in the control panel and load feeders. However there is no provision to take the entire load of pulveriser on DG1/DG2 in the event of breakdown of hired DG set.

4.2 SELF GENERATION

HSD is the main fuel for the DG sets. HSD consumption in the DG set is monitored from the service tanks and recorded in the log book. The kWh generated are monitored from the analogue kWh meters in control panels.

In order to assess the specific energy generation ratio (SEGR), load trials were conducted and the details are tabulated below:

DG Set Type	kWh Generated	HSD Consumed litres	SEGR
125 kVA	63.96	28.64	2.23
160 kVA	34.35	13.93	2.46

It is observed that the SEGR figures are low. The month-wise SEGR for the year 1996 is tabulated in Appendix - 4/2.

4.3 OBSERVATIONS, ANALYSIS AND FINDINGS

A. Optimal Loading of DG set 1 & 2

During the test period the DG sets were observed for loading and the details are tabulated as follows.

Time : 11 am - 2.40 p.m dt. 03.05.97

DG Set Type	Voltage (Volts)	Avg. kW	Avg. Current (Amps)	DG set Rating (kW)	% Loading
125 kVA	447	50.4	94.75	100	50
160 kVA	446	62.8	102.35	128	46.2

It is observed that both the DG sets are loaded below 50%.

At present there is no flexibility or provision to shift or share loads between the DG sets or with BSEB grid. In a situation when one DG set is poorly loaded and working at 47% load factor, the spare capacity available on this set cannot be utilised, because a load connected to the other DG set circuit cannot be transferred to this DG set, because of non-availability of changeover switches or parallel bus bar arrangement. It is always better to have provision to shift and share loads between DG sets. In order to achieve this feature, changeover switches for specific load transfers could be fitted on the distribution Board. This is discussed in detail in Chapter-3.

The spare capacities available on the DG sets are as follows:

DG Set Type	Spare Capacity in %
125 kVA	50
160 kVA	53.8

The above data indicates low capacity utilisation leading to high cost of energy. It is suggested that the loading of the electrical supply system be improved by better load management and planning. The total load at present is 113.2 kW and this could be easily managed by operating one DG set of 160 kVA where % load will be 88%..

When BSEB supply fails the present loading pattern is as follows:-

Item	Present Load	Rated Capacity kW	Spare Capacity kW
125 kVA	50.4	100	34.6
160 kVA	62.8	128	65.2
BSEB Grid	-	-	-

The proposed load programme is tabulated as follows:

Item	Load kW		Rated Capacity kW
	BSEB ON	BSEB OFF	
125 kVA	-	-	100
160 kVA	-	113	128
BSEB Grid	113	-	-

Only during unusual peak loads of above 88% it should be proposed to operate the 2nd DG set. Operating 160 kVA DG (128 kW max.) at 113 kW where the typical township load forms 40% is justified since the nature of load is not constant and there are starting kicks. Hence it is recommended that 2nd DG set should be operated only when such a necessity arises.

The above proposed method has the following advantages:-

- ☞ when BSEB grid power is ON, both the DG sets are OFF
- ☞ when BSEB grid power is OFF, the entire load is taken only by the 160 kVA DG set. The 125 kVA DG set will be standby to meet the peaking load.

This should be judiciously viewed since by partial shedding of township loads during day time, operation of 2 nos. DG set would be avoided. It is to be noted that in the first case both the DG sets will be resting. In the second case when BSEB is OFF, the load factor of the 160 kVA DG set would have been improved, thereby achieving higher SEGR. The 125 kVA DG set would be standby thereby saving fuel.

As can be seen from Appendix - 4/2, the average SEGR is 2.6. By improving the load factor on the DG sets, as explained in the proposed load programme, the SEGR could be improved to 3.40.

The BSEB grid power is not available for approximately 480 hours per month during which time the DG sets are operated. Because of the better load factor only the 160 kVA DG set need to be operated as discussed in paragraphs above.

Appendix 4/5 gives the total operating hours of DG sets during 1996-97.

Total running hours of the DG sets are as follows:

DG Ref.	1996-97 Avg. In /month	April'97
DG1	167	326
DG2	198	289
DG hired	235	442

Improvement in the load factor of the DG set will have a marked impact on fuel consumption. By improving the SEGR from 2.66 (at present) to 3.40 by rationalising load management the fuel consumption ratio per kWh generated could be reduced.

The following tabulation highlights the scheme.

Year	Actual HSD consumption (ltrs)	Actual kWh generated	Ltrs/ kWh Ratio	GMS/ kWh Ratio	PCRA Norm @ 3.40 SEGR GMS/kWh	Potential Savings	
						GMS/kWh	lit/kWh
1996	93,125	2,48,872	0.374	307	21C	97	0.118

PCRA has made extensive data collection and research and found that medium engines with good load factor and SEGR of 3.40 achieve a fuel consumption to kWh ratio of approx. 210 gms/kWh. By improving the load factor and SEGR, savings could be achieved in HSD fuel consumption

Annual Savings in HSD fuel oil	=	0.118 X 248872
	=	29367 ltrs
Value of Annual Savings	=	29367 X 9
	=	Rs. 2,64,303/-
Considering 60% of above savings to be realised, the net annual savings	=	Rs.1.60,000/-
Cost of Implementation (Mechanical & Electrical Retrofits)	=	Rs. 1,50,000/-
Simple payback period	=	1 year

B. Energy Balance of DG sets

Energy Balance was carried out on the DG sets, to evaluate the thermal efficiencies. It was observed that the thermal efficiency of 125 kVA DG set was 21.7% and 160 kVA DG set was 24%.

The heat balance details of 125 kVA & 160 kVA DG sets are tabulated as below:

Heat Balance of 125 kVA DG set

Item	kcal/h	%
Heat Input by fuel	253800	100
Heat output		
a Thermal Efficiency/ Electricity Generation	55006	21.7
b Heat given off by Radiator	1,33,747	52.7
c Heat loss to flue gas	51,088	20.1
d Surface Loss + unaccounted losses	13,959	5.5

Heat Balance of 160 kVA DG set

Item	kcal/h	%
Heat Input by fuel	123120	100
Heat output		
a Thermal Efficiency/ Electricity Generation	29,541	24
b Heat given off by Radiator	45274	37
c Heat loss to flue gas	28520	23.2
d Surface Loss + unaccounted losses	19785	15.8

The detailed calculations are given in Appendix - 4/3 and Appendix - 4/4.

C. WASTE HEAT RECOVERY

Waste heat recovery from the exhaust flue gases could be considered for producing hot water. Approximately 45032 kcal/h waste heat is available for the 160 kVA DG set. The 125 kVA DG set will contribute 36931 kcal/h of waste heat, if operated.

The 160 kVA DG set running 5760 hours/year will generate 40,000 ltrs of hot water at 55 °C per year.

D. COOLING TOWER

Presently the DG sets are cooled by radiator. But test measurements conducted on the DG sets revealed hot running of the sets.

The following tabulation highlights important parameters measured.

DG Set Type	Ambient temp. °C	Water temp °C (Rad.)	Cyl. Body temp °C	Cross sectional area of Rad. m^2	Rad. exit air temp °C	Rad. exit air velocity m/s	Dry bulb temp °C	Wet bulb temp °C
125kVA	31	56	40	0.78	48	9.2	31	28
160kVA	31	78	46	1.15	48	3.8	31	28

It is observed that the effectiveness of the radiator of the 160 kVA DG set is poor. Not only is the water temp. high but also the flow of air through the radiator fins is poor. It is suggested that in the interest of long term life of the engines and better maintenance, the radiators are replaced by a cooling tower. Not only will the cooling be more effective, but also the maintenance and upkeep will be better.

Technical data for cooling towers is highlighted in Appendix - 4/6.

4.4 RECOMMENDATIONS

A. Load Management on DG sets could be rationalised.

B By improving power factor and utilising the 160 kVA DG set capacity more fully, the 125 kVA DG set need not operate, thereby saving HSD fuel oil.

C Load transfer switches could be provided in the control panel to shift loads between DG sets.

D. The Radiators of the engines could be replaced by a single cooling tower.

E Measures for lubrication oil conservation for DG sets is given in Appendix-4/6.

F. General Operating tips for fuel efficiency for DG sets are given in Appendix - 4/7.

4.4 SUMMARY OF POTENTIAL ENERGY SAVINGS

Sl. No	Proposal	Energy Savings HSD		Cost of implementation Rs.	Simple payback period Years
		Ltrs/year	Rs./Year		
1.	Improving Load Factor and SEGR of DG sets (Run only 160 kVA DG set)	29367	1.60 lacs	1.50 lacs	1 year

5.0 ELECTRICAL DRIVES

This section covers the study of electric drives. It includes detailed analysis of motor loading operations based on the measurements/observations during study and the data gathered from the plant personnel.

5.1 FACILITY DESCRIPTION

The majority of electrical loads are drives used for various applications, like conveyors, fans, pumps, etc. The areawise loading details are give below :

Area	Connected load kW	Approx. Operating Load
Kaolin Plant	84	50.0
Water Pumping Systems	48.5	24.0
Pulveriser 1 & 2	84	65.0
Crusher - 1	33.5	12.0
Crusher - 2	30	17.0
Ropeway	18.5	11.0
Miscellaneous lighting and township loads	200 (Approx.)	60.0

The range of motor drives include up to 45 kW rating and motors are squirrel cage induction motors, (except one motor of 45 kW. Slip ring). Majority of the motors are old and rewound several times. However Kaolin plant and pulveriser - II units have new motors. Total connected load of motors is 300 kW. Motors up to 15 hp have DOL starting and above 15 hp, λ- Δ controllers are used.

For the purpose of study most of the operating motors have been taken for on line measurement. Suitable recommendations for energy efficient measures, have been discussed and proposed for various drives.

5.2 OBSERVATIONS, ANALYSIS & FINDINGS

A. Motor Loading Pattern

The motor operating parameters were observed and electrical parameters have been measured with the help of portable hand held power analyser and microprocessor based, 3 phase power and demand monitor. Based on these measurements the performance of the motors have been evaluated for further analysis. The measured motor loading parameters are presented in Appendix - 5/1 and discussed below.

% Load Range	# of motors (%)
20 - 40	9
40 - 60	7
> 60	15

The production in Kaolin plant is for 10 hours, 16 hours in mines and in pulveriser section it is now proposed for 3 shifts working. The operating voltage frequency is varying between 388-440 V and 47.9 to 52 Hz. The drives are either supplied from BSEB or DG. In most of the cases drives are found to be directly coupled or driven by v-belt drives.

B. Energy Efficiency in Drive Systems

General

(i) The operating voltage is varying between 390 - 440 V on a typical working day. However this fluctuation is not significant though very high/low voltages can cause burn out of the motors. However, suggestions for better voltage co-ordination have been already discussed in chapter 3.

(ii) DG Sets are operated most of the time since records show that only 50% of time, the BSEB supply is available. However, DG sets are operated at frequency of 51-52 Hz, and voltage levels as high as 450 V. Detailed measurements of drive power parameters indicate that frequency and voltage levels can be lowered for optimum loading and energy efficiency. The details of observations are highlighted in Chapter 3.0.

(iii) The plant is extensively using V-belts for drives. It is suggested that flat belts be used. These are energy efficient resulting in energy saving to the tune of 2 to 5%. It also facilitates the plant for standardisation of belts.

(iv) Some of the motors are situated for from the LT panel, and since the distribution losses are significant, installation of capacitor banks at load end will minimise losses. However use of PF controller/soft starter assumes greater significance here, since this is the optimum method for improving pf and operate drives to minimise line losses (in addition to saving magnetic losses). These aspects have been dealt in subsequent chapters.

(v) The load on conveyor motors is below 50% and this varies due to fluctuation in production rate. Frequent start/stop cycle is also observed due to power problems. It is recommended to use Electronic PF controller /soft starter for the application, which operates the motor at appropriate voltages sensing the load on the motor. The potential benefits and details are given in subsequent chapters.

C. Star mode of Operation of Underloaded Motors

Motors loaded below 40% should be tried out for operation in star mode, provided starting torque requirements are met. However, the above proposal should be tried out for the following motors.

Drive	Rated kW	Operating kW
Tank agitator	3.7	1.1
Screen motor	3.7	1.2

Such an exercise of operating delta connected motor to operate permanently in star mode reduces the motor rating by 1/3rd and hence the % load in λ connected mode will be 100% and pf will be > 0.9 lag. Marginal energy savings accrue due to reduction in losses in motors.

D. Unbalanced Voltage Levels

The plant installation has about 20-30% of single phase loads i.e. mainly on township feeders. Distribution of single phase loads have been balanced however this depends on switching practice. Any unbalanced voltage operation of 3 phase loads up to about 2% can result in 8% increase in losses. This aspect was looked into while carrying out measurements and voltage unbalance was observed on borewell feeder.

13-25 hrs	
VR-N	254
VR-N	258
VB-N	262

Such observations should be carried out periodically so that unbalances are kept within 1% of supply voltage. The following illustration should be used.

$$\% V_{(Unbalance)} = \frac{\pm (V_{min} \text{ or } V_{max} - V_{average}) \times 100}{(V_{min} \text{ or } V_{max})}$$

Plant management should initiate action to balance the load on three phases of distribution feeders so that such unbalances are avoided.

E. Low Watt Loss HRC Fuses

The HRC fuses used in main switches of distribution system should be that of low watt loss.´ The procurement action should be considered in phases since energy savings due to the `low watt loss' on continuously energised fuse switches will be significant. Details of addresses are given in chapter "Retrofits"

F. General

- The exhaust fans of toilets and /offices should be wired through timers and these should be programmed for switch off during lean periods and holidays.
- The history card for motors should be maintained and the record of no load currents of rewound motors should be maintained.
- Depending on application, electronic controller (soft starters) can be procured for the machine drives as original equipment.

- For old and motors rewound more than 3-4 times, high efficiency motor should be procured and installed or whenever new installation is proposed for production /process.
- Use always electronic energy and panel indicating meters.
- Use LED displays instead of pilot lamps for control panels.
- Measure and decide motor kW (%) loading and not by ampere loading. Necessary instruments for monitoring should be procured.
- Avoid belt drives and prefix direct coupling for drives.
- Use flat belt and flat pulleys as original equipment for drives.

5.3 PROCESS DRIVES - ENERGY EFFICIENCY PROGRAMME

A. Kaolin Plant

The Kaolin pilot plant drives include fans, pumps, agitators, etc. The measurements of power parameters of drives are given in Appendix - 5/2. The pumps and fans are loaded optimally above 60%. The supply and exhaust fans of hot air generator were studied in detail to assess energy consumption parameters at various voltage and frequency of supply. Since DG is supplying power for most of the production period, observations indicated that frequency is always above 52 Hz and voltage is above 430 V.

Details	V	I	P.F.	kVA	kW	kVAr	Hz
Exhaust fan 22 kW	427	22.5	0.82	16.7	13.8	9.5	51.3
	413	21.8	0.82	15.6	12.7	8.9	51.0
	404	20.7	0.83	14.5	12.0	8.0	50.6
	405	20.4	0.81	14.3	11.6	8.5	49.1
	421	22.0	0.83	16.2	13.5	9.0	51.1
Supply fan 11 kW	405	8 5	0.96	6.0	5.7	2.0	49.1
	403	7.9	0.94	5.5	5.2	2.0	49.1
	418	9.6	0.87	6.12	7.0	3.5	51.1
	419	8.7	0.96	6.0	6.5	2.5	51.1
	419	11.6	0.96	8.1	8.5	1.8	51.1
Main supply for Kaolin dryer	405	43.9	0.70	30.8	21.6	21.9	49.1
	420	45.4	0.69	33.0	22.7	23.9	51.1
Combustion fan 1.5 kW (I_{start} = 66.7)	415	2.0	0.59	1.5	0.85	1.2	50.7 25% open
	415	2.1	0.62	1.5	0.93	1.2	50.7 30% open
	415	2.2	0.66	1.5	1.04	1.2	50.7 45% open
	415	2.25	0.67	1.6	1.08	1.2	50.7 Fully open
	415	2.1	0.59	1.5	0.88	1.2	25% open

From analysis of above readings taken on printer, it is observed that when the frequency is high, power consumption is also high on the cube loads especially from fans. It is recommended to log and monitor DG frequency and regulate between 49 to 50 Hz on load, so that voltage is maintained between 415 - 425 V on the alternator.

Optimising voltage to load and precise monitoring of DG frequency is expected to result in 1.8 kW and 0.8 kW reduction fan power consumption (for exhaust and supply fans) in addition to :

* minimising magnetic losses in several other drives
* improvement in pf of operation

As such production rate was checked up with Kaolin plant at 49-50 Hz generating frequency and there was no change in production process. Considering DG operating hours to be 3000 per annum for Kaolin production, potential energy savings to an extent of 7800 kWh can be realised on BSEB incomer. However this effect can not be realised since control of grid frequency is not possible.

B. Water Pumping Systems - Case Study - 20 HP Submersible Pump

The submersible pump of 20 hp is operated for 12 hours in a day for raw water supply from tank and two centrifugal pumps are standby (presently not in service due to leakages). There are five borewells of 2.5 hp for augmenting requirement for plant/township. However, power supply to 20 hp borewell submersible pump is taken through 35 sqmm cable over 300 mts distance and 15 m^3/h water is pumped to the overhead tank. (from open water pond).

The measurement of load details are give below :

LOADING OF - BOREWELL PUMP MOTOR - 20 HP

Date : 06.05.97

Time	V	I	kW	PF	kVA	kVAr	Hz
11.00	433.0	31.4	18.3	0.78	23.6	14.9	52
11.10	401.00	28.80	15.70	0.79	20.00	12.40	
11.15	413.00	29.50	16.40	0.78	21.10	13.20	
11.20	438.00	30.90	17.80	0.76	23.50	15.30	52.2
11.25	437.00	30.30	17.30	0.75	23.00	15.10	
11.30	434.00	31.20	18.00	0.77	23.40	15.00	52.2
11.35	427.00	30.20	17.30	0.77	22.40	14.20	
11.40	423.00	30.10	17.20	0.78	22.00	13.80	
11.45	402.00	27.50	13.80	0.72	19.10	13.30	51.0
11.50	369.00	24.50	10.40	0.66	15.60	11.70	
11.55	414.00	29.10	15.70	0.75	20.90	13.80	
12.00	419.00	30.10	17.20	0.79	21.90	13.50	
12.05	414.00	31.20	18.00	0.80	22.40	13.30	
12.10	418.00	30.60	17.50	0.79	22.10	13.50	
12.15	412.00	28.70	15.70	0.77	20.40	13.10	51.1
12.20	405.00	29.00	16.10	0.79	20.30	12.40	51.5
	407.00	28.5	15.5	0.77	20.2	13.0	51.1
12.30	434.00	29.5	16.4	0.74	22.1	14.9	51.3

* DG frequency was reduced to 45.5 Hz

The power consumption on a 15 kW motor is as high as 18.0 kW load current of 35-40 amps were observed during trials. The frequenc

of DG was at 52.2 Hz and after regulation to 50 - 51 Hz, load on motor got reduced by 2.5 kW. However, there was no change in the pumping systems operation which was checked up. The measurements were carried out before and after backwash of sandbed filters.

The aspects of frequent start/stops, under/over voltage operation and problem of ampere overload on motor was discussed. It is also reported that motor has already been rewound once. However existing thermal overload relay was not observed to be tripping during under voltage also. Voltage drop during starting of motor at load end feeder cable was observed to be 10 - 12 V.

The analysis of measurements and computations of distribution losses indicate that annual energy savings of 1723 kWh can be achieved by installing 10 kVAr capacitor bank at load end (which is 300 mts from power source).

Analysing the problems of operation, it is recommended to install electronic starter for the 20 hp borewell pump motor, which will optimise voltage of operation of the said drive and minimise ampere load drawn by motor. Implementation of above measure is expected to yield energy savings by minimising magnetic losses in the motor in addition to :

* Offering best protection for O/L, u/v
* Reduced kVA drawn from supply
* Softstart /stop avoiding wear out of rotating parts

The investment for such a retrofit is expected to be Rs.31,100 and the existing starter could be used elsewhere. Considering the energy savings potential and given the system advantages/protection features, etc. the payback will be 2-3 years. Details are given in Appendix - 5/3.

C. Pulveriser Plant

Pulveriser - I - 60 HP Slip Ring Motor Drive

The loading details of pulveriser plant drives are given in Appendix 5/2.

The drives consist of hammer mill, small conveyor and sticher. The main drive is a slip ring motor of 60 hp, driving hammer mill with integral fan for material transport. The motor is loaded from 65% up to full load depending on feed rate which is through a pawl / rachet drive. Presently the feed rate from the pawl rachet drive is manually stripped or adjusted during overfeed (sensing overload on the motor read from ammeter). This practice is carried out manually requiring the presence of an operator.

The 60 HP motor is loaded optimally, however tripping is observed whenever there is an overload due to exceed feed rate. The starting/stopping is frequent due to frequent power outages. The slip ring rotor controller is sometimes put to high duty cycle, thereby causing overheating. This overheating of controller is also due to loose connection of starter controller which was pointed out to the staff for rectification. The drive receives power supply from 180 kVA hired DG set for most of the time due to BSEB power failure.

The observations of load readings are give below :

Pulveriser - 60 Hp Motor Load Readings

V	I	P.F.	kW	kVA	kVAr	Hz	Remarks
433	57.9	0.85	37.1	43.5	22.7	51.9	Tripped due to O/L
431	66.3	0.86	42.4	49.4	25.4	51.7	-
401	50.8	0.84	29.5	35.3	19.3	48.7	3 Mt bag
414	63.1	0.88	39.6	45.2	21.8	50.1	2 ½ Mt bag
422	58.9	0.83	35.8	43.1	23.9	51.1	3½ Mt bag

The analysis of load readings indicate that drive power consumption is decreasing when frequency is lowered from 51.9 Hz. This was measured and analysed in a computer after carefully observing the production schedule.

By optimal adjustment of frequency of generation it is observed that the hammer mill kW load could be minimised by 5-10% without affecting production/process.

Pulveriser - II Vertical Roller Mill and Fan Drive

The roller mill motor (30 hp) is having star delta starter with fan drive interlocked for process operation. The feed rate is manually controlled and the starting/ stopping is frequent due to power outages necessitating changeover of supply.

Similar measurements taken on 30 hp fan are tabulated below :

Loading Parameters of Motor Coupled to Pulveriser - II Fan Motor

V	I	P.F.	kW	kVA	kVAr	Hz
Pulveriser Fan - 30 HP						
417	32.3	0.81	19.0	23.5	13.8	50.8
399	31.0	0.81	17.3	21.4	12.6	48.3
434	32.8	0.81	20.0	24.7	14.4	51.4
413	32.3	0.81	18.8	23.1	13.5	49.7
434	33.6	0.82	20.5	25.2	14.6	51.9

The power supply to this drive was often interrupted due to power supply change over. The kW load at normal frequency has shown a reduction of 1.5 kW (minimum). The star delta starter was observed to be changing over fast even before the fan motor would attain rated rpm. This was also noticed by the jerking noise of drive during change over from star to delta. After detailed trials conducted, this was practically adjusted sot that the star delta starting and change over to Δ was smooth giving the optimum benefits of controller provided .

Such measurements / trials conducted on various drives assist in reducing the starting kVA of BSEB and DG incomer. The optimum system benefits and energy savings are best realised when frequency control of operating DG is regularly monitored to operate between 49.5 - 50.5 Hz . It is recommended to monitor and log DG frequency every 15 mts since DG supply is extended for atleast 50% - 60% of production time in a year.

The star-delta starter had a change over period of 3 mts from star to delta with 8V drop in supply voltage while starting. Trials were carried out to analyse the operating load parameters and effectiveness of λ -Δ changeover. Details are tabulated below :

Vertical Roller Mill - 30 Hp

V	I	P.F.	kW	kVA	kVAr	Hz	Remarks
437	28.5 I_{st} = 48/121	0.74	15.9	21.5	14.5	52.1	λ -Δ C/O = 3 Mt. V drop = 8 V
434	26.8 I_{st} = 53/88	0.73	14.7	20.2	13.9	52.1	λ -Δ C/O = 6 Mt. N/L V drop = 4 V
435	34.2 I_{st} = 53/38	0.79	20.4	25.7	15.7	51.8	λ -Δ C/O = 9 secs V drop = 1 V on load

The star delta change over was observed to be fast, with a starting current surge of 48A/121A having a change over time of 3 sec. This was creating a jerk in the driven equipment, during changc cover from star to delta connection even before the motor drive could attain rated rpm.

Trials were carried out to minimise starting current during λ -Δ starting and it was finally adjusted to optimise λ -Δ change over period to 9 sec. This affords smooth start and change over to normal operation (in Δ mode) with a maximum current of 67/80 A and just 1 volt drop (even with load on hammer mill). The above results in smooth loading of DG Set also and marginally assists to minimise demand on incomer.

Energy savings by way of optimal setting of frequency between 49.0 50.5 Hz and voltage level of 420-430 volts are computed as below from the detailed measurements carried out on various drives.

Plant	Rated kW	Hourly Energy Savings kW
Kaolin Plant		
Supply fan	11	0.8 (Measured)
Ex.fan	22	1.5 (Measured)
Borewell Pump	15	1.0 (Measured)
Pulveriser Section		
Hammer Mill	45	1.5 (5% of 29 kW assumed)
Roller Mill	22	1.0 (5% of 29 kW assumed)
Mill fan	22	1.0 Measured
Misc. Other drives of 75 kW load	-	1.8 (2.5% of 75 kW)
Total	-	8.6 kW

Considering that DG sets are supplying the production loads for 3000 hours per annum, the proposal is expected to yield an annual energy saving potential of 25,800 kWh from DG sets. The above works out to Rs.90,300/- per annum considering the cost of fuel only.

The proposal should be implemented by installing operator alarm systems for these DG sets which gives an alarm at 50.5 Hz and 49.0 Hz DG frequencies. The above alarm systems are expected to cost Rs.5,000 per unit (for three DG sets) which would facilitate the operator to take corrective action. The above details should be made known to the operator concerned for awareness and prompt logging of data.

5.4 Mines, Crushers and Ropeway

Crusher - I and II - Softstarters for Conveyor Drives

The main crusher drive being driven by engine, the auxilliary systems comprise of 4 belt conveyors. The measurements of load on belt conveyors are given below :

Crusher - I	HP	A	PF	kVA	kW	% Load
Belt conveyor	10	4.5 - 12.2	Low 0.85	4.5 8.7	1.5 5.7	20.0 76.4
Screen conveyor	5	8	0.3	6.3	1.2	32
BSP Conveyor - 1	10	6.6	0.5	4.6	2.1	28
BSP Conveyor - 2	20	5.0	0.44	4.3	2.5	17
Crusher - 2 conveyor	20	14 -17.2	0.57 - 0.76	13 -14	7.2-7.5	48-50
Ropeway main drive	20	8.9 - 14	0.65/0.8	8.7-12	7.2	48

However the load on 20 hp slip ring motor for ropeway main drive is optimal. The belt conveyors are variably loaded depending on crusher operation and idle period is also high. Crusher - 1 belt conveyor of 10 hp is loaded occasionally to 76% whereas the load on other conveyors are less than 50%.

The operating pf is observed to be low due to load on motor being less than 50%. It is recommended to install pf controllers/soft starters for these conveyors. The above controllers optimally adjust the voltage, sensing the load on drive motor and such a retrofit is expected to yield energy demand savings by ramping starting sequence.

The additional advantages for the drive are quite significant (which can not be quantified) on detailed below .

* Mechanical wear and tear due to frequent start/stop during power failure is reduced.

* Due to reduction in starting kVA drawn from mains and especially on DG power system, maximum loading DG up to 90% can be proposed (without the necessity of 10-15% cushion on DG rating for restarting motors that have tripped).

* Improved PF operation at all load cycles motor heating at low load will be minimised. Implementation of this measure is expected to yield an annual saving potential of 19,527 kWh Rs.25,522 with a demand saving of 18 kVA, cost of annual energy savings works out to Rs.46,527/- with an implementation cost of Rs.2,00,500/-. Details are given in Appendix - 5/3 and the simple payback period works out to as 3 - 4 years.

5.5 Optimum Sizing & Use of Energy Efficient Motors

The plant has installed motors which are standard efficiency type having been rewound more than 3-4 times. The loading pattern of 50% of motors are below 60%. However the motors used for pulveriser - II (fan and mill) are new and 91.5% efficient type.

Energy efficient motors (EEM's) are offered by most of the manufacturers and their operating efficiencies will be higher by few % points. EEM's operate with reduced losses and their operating pf will be good even at peak loads. However energy efficient motors cost 30-40% more than standard efficient motors. It is recommended to downsize the rating of existing motor (matching to the load) and replace the existing old motors (especially those motors which are rewound several times). The released motor could be available as spare and such a programme being capital intensive, could be proposed in phases.

Details of optimum sizing and replacement options are worked out in Appendix - 5/4. The potential energy savings by implementation of above measure works out to 23808 kWh (Rs.78535/-) with an implementation cost of Rs.1,26,000. The computed payback period of 1.6 years will decrease with proposed increase in energy costs.

5.6.0 PULVERISING PLANT - PROCESS MODIFICATIONS

At present the Bauxite ore is loaded into main hopper by means of a wheel loader and the material is fed onto the belt conveyor leading to the feeder hopper with the help of a gate opening at the foot of the main hopper which is controlled manually by an operator. A brief process flow chart is enclosed In Appendix - 5/5.

The operator also keeps note of the level of the feeder hopper and switches on and off the belt conveyor depending on how full or empty the feeder hopper is. It is suggested that this section be mechanised so that the operator could be released for work in some other department.

5.6.1 PROPOSED SYSTEM

At the bottom of the main hopper a short inclined chute could be provided. The incline could be around 25 to 30 ° to enable movement of the feed. The chute could also be vibrated with the help of external mounted electromechanical vibrators which will facilitate smooth material flow. At the end of the chute a pneumatically operated sliding gate of the vertical type could be installed which will control the feed rate to the conveyor. The exact feed rate will be shown with the help of electronic belt weighers (load cells) mounted below the belt at the feed end. Based on the set feed rate, the sliding gate opening could be adjusted.

At the delivery end of the conveyor, the material will fall in to the feeder hopper for distribution into the hammer mill and roller mill. It is suggested that instead of the funnel type feeder hopper as at present, a smoother controlled feeder hopper be installed, so that material flow is easier. The hopper could have a smooth 30 ° taper at the bottom on the entry side.

In the case of the hammer mill, it is suggested that the feed system be fitted with a variable speed control AC motor, so that the pawl in the ratchet and pawl arrangement could be eliminated. The electrical control system for the feeder drive will have a feature which will sense the load in amperes of the main motor and depending on the set target amperage the feed motor could be slowed down or even stopped to enable material to be pulverised and the motor load to come down. Once the motor load comes down, the feed motor will speed up and maintain normal feed rate. This arrangement will release one operator from the hammer mill, who is now all the time monitoring the main motor current and controlling the ratchet and pawl system to slow down the feed rate until the main motor load comes down.

In the case of the feed belt conveyor system, capacitance sensors could be fitted in the feeder hopper to control high level and low level. Depending on the level control, the belt conveyor could automatically start and stop.

Annual potential savings in cost (Due to release on man power)	= 2 x 5000 x 12
	= Rs.1,20,000/-
Cost of implementation (Mechanical & Electrical retrofits)	= Rs.1,75,000/-
Simple payback period	= 1.5 years

The efforts to mechanise/automate the feeding system at pulveriser (hammer mill) will avoid frequent tripping of machine and restarting, thereby production schedules could be met easily. The loading on DG generation system will improve without dip in voltage during start up.

5.7 RECOMMEDATIONS

A. Energy Efficient Operation of Process Drives

The drives coupled to fans, mills and conveyors are operated on DG supply for more than 50% of production period. Whereas DG is operated above 51.5% Hz and 450 volts most of the time without regulating the frequency as per load. Optimum operation of DG sets at 49-50 Hz for drives is expected to reduce kW loading of the DG set by 5-10%. This has been tried out and by analysing measured data, it is observed to yield the potential energy savings as under :

Refer Section 5.3 A,B,C for analysis of drives in Kaolin plant, pumping systems and mines.

Annual energy savings potential	=	25,800 kWh
Cost of energy savings @ Rs.3.5/kWh	=	Rs.90,300/-
Cost of Implementation (for frequency alarm system to monitor DG frequency)	=	Rs.15,000/-
Simple payback period	=	Less than ½ year

B. Softstarter for Conveyor Motors

The operating pf of conveyor motors in mines is observed to be low due to load on motor being less than 50%. It is recommended to install pf controllers/soft starters for these conveyors for energy and demand savings.

The additional advantages :

* Reduced mechanical wear and tear due to frequent softstart.
* Reduced kVA load and instantaneous jerk load on DG minimised.
* Improved PF operation at all load cycles and motor heating at low load will be minimised. Implementation of this measure is expected to yield an annual saving potential of 19527 kWh and a demand saving of 18 kVA. (Refer Appendix - 5/3 for details).

Cost of energy savings	=	Rs.46,527/-
Cost of Implementation	=	Rs.2,00,500/-
Simple payback period	=	3 - 4 years

C. Optimum Sizing & Installation of Energy Efficient Motor

The installation of optimally sized energy efficient motors (EEM's) are recommended wherever motors are old, rewound several times and underloaded. It is proposed to replace 9 motors in Kaolin and mines area by EEM's which is expected to yield potential energy saving benefits. (Details are given in Appendix - 5/4).

Annual energy saving potential	= 23,808 kWh
Cost of annual energy savings	= Rs.78,565/-
Cost of implementation	= Rs.1,26,000/-
Payback period	= 1.60 years

D. Pulverising Plant - Process Modifications

It is proposed to install mechanised feed belt conveyor systems for transporting bauxite ore to the hammer mill. It is also suggested to install an AC motor with speed controller for feed rate management of bauxite to hammer mills-1, so that deployment of manpower could be avoided. This proposal is expected to relieve deployment of 2 personnel for manuals. Implementation of above measure is expected to save about Rs. 1.20 lakhs from manpower costs. The proposal with mechanical and electrical retrofits is expected to cost of Rs. 1.75 lakhs giving payback of 1.5 years. (Ref. Sec. 5.6).

E. General Recommendations

1. Star mode operation of tank agitator and screen motor should be considered. (Refer 5.2.C).

2. Use of flat belts and flat pulleys for compressors, apron feeder drive (crusher), fans in Kaolin and pulveriser plant should be considered to yield energy savings. (Refer 5.2.B (I).

3. Any unbalance in voltage above 1% should be examined for corrective action.

4. Use of low watt loss HRC fuses above 100 A rating should be considered.

5.8 SUMMARY OF POTENTIAL SAVINGS

Sl No	Proposal	Energy Savings		Cost of implemen-tation	Simple payback period
		kWh/yr	Rs.Lakh/Yr	Rs.Lakhs	Years
1.	Energy efficient operation of process drives	25,800	90,300	15,000	< 0.5
2.	Use of soft starter (electronic energy savers) for lightly loaded motors	19,527 18 KVA M.D	46,527	2,00,500	4.3
3.	Optimum sizing and installation of energy efficient motors	23,808	78,565	1,26,000	1.6
4.	Mechanisation of feed conveyor and feed system (Hammer mill) in pulverising plant	-	1,20,000	1,75,000	1.5
TOTAL		**69,135 (18 kVA MD)**	**3,35,392**	**5,16,500**	**1.54**

6.0 DIESEL DRIVEN MACHINERY

6.1 FACILITY DESCRIPTION

A Earth Moving Machinery

These equipment play a vital role in the mining operations. The various machinery are tabulated below:

Sl.No	Item	Qty (Nos.)	make
1	Ripper Dozers	2	Komatsu, BEML
2	Hydraulic Shovels	3	Tata-Hitachi, (L&T Poclain)
3	Dumpers	6	TEREX, HM

These are employed for bauxite excavation and transportation to ropeway and also for clearing overburden.

B Crushing & Screening Plant Machinery

On the Southern side of Lohardaga mines, the crushing and screening plant is located and since BSEB grid power is not available all the time, the critical jaw crushing equipment are powered by Diesel engines. The metal grade (large) Jaw crusher is powered by a 295 hp caterpillar engine and the refractory grade (small) Jaw crusher by a 180 hp caterpillar engine

6.2 OBSERVATIONS, ANALYSIS AND FINDINGS

A. Earth Moving Machinery

Studies were conducted on Diesel Driven Machinery using portable fyrite kit and other instruments..

i Exhaust Gas Analysis

The tabulation below gives details of measurements done on various equipment.

Sl. No.	Item	% CO_2 (Loaded condition)	Exhaust Gas temp °C
1	Ripper Dozer (KOMATSU)	4	204
2	Loader (Tata-HITACHI)	4.5	206
3	Loaded (L&T Poclain)	14	207
4	Dumper (No.4)	5.5	206
5	Dumper	4.25	208
6	295 HP CATERPILLAR ENGINE	3	223
7	180 HP CATERPILLAR ENGINE	3	207

PCRA recommendation is to achieve a % CO_2 greater than 9.

B Caterpillar Engines at Crushing Plant

A detailed study was undertaken of the two engines at the crushing and screening plant. The data collected after measurements is tabulated below:

Sl. No	Item	% CO_2	Ex. Temp. °C	Rad. Air Velocity m/s	Rad. Exhaust temp °C	Cyl. Body temp °C	Ambient temp °C	Water temp °C
1	295 hp Engine	3	223	7.9	38	37	28	75
2	180 hp Engine	3	207	3.4	32	36	28	80

It is observed that the Radiator air velocity is low for the 180 hp engine.

The entire crushing and screening area is enveloped in dust caused by material handling and not only mechanical items such as radiators get choked with dust and restrict air flow, but also electrical switches are prone to short circuiting and flash over.

Both the engines are provided with power take off shafts which can drive through belt drives a 25 kW alternator from the 295 hp engine and a 25 kW alternator from the 180 hp engine. This electric power generation from the power take off shafts will render the crushing and screening plant in totality self sufficient as regards electric power requirements for conveyors, screens and feeders.

Estimated Annual Energy Savings	=	1,18,440 kWh
Annual value of savings	=	Rs. 3,90,852/-
Cost of Implementation	=	Rs. 2,25,000/-
Simple payback period	=	0.58 year

Calculation details are given in Appendix - 6/1

C. Dumper/Loader Cycle Time Analysis

Two Dumpers and one hydraulic loader form a team. One team works on the overburden, whilst the other team works on the Bauxite ore. The third team is deployed either on overburden or Bauxite depending on workload and daily plan requirements. During the study period only two teams were functioning, as the third team could not be formed since both the dumpers were taken up for maintenance.

The data collected at the mine sites on the two teams are as follows:

Sl. No	Group	Wait Time	Loading Time	To & Fro Travel Time	Dumping time	Loading time for one fill into dumper
1	I	4 mts	3 Mts. 19 SCEs	6 Mts. 6 SCEs	1 Mt. 53 SCEs	19 SCEs
2	II	-	4 mars. 36 SCEs	19 Mts. 12 SCEs	59 SCEs	19 SCEs

The above data will be useful to compute overall cycle time for dumper depending on to and fro distance.

D. Dumper Fuel Consumption

During the study period 4 dumpers were operational. i.e Nos. 1,3,5 and 6. Dumper I had a defective hour-meter and dumper 6 had a fixed screen in the fuel tank entry pipe preventing entry of dip stick. Hence these two dumpers could not be studied. Dumper 3 and Dumper 5 were taken for fuel consumption study. However after one hour of operation Dumper 5 sprang a heavy leak in the fuel oil line and the study had to be abandoned.

Therefore Dumper-3 was only studied. A dip stick was fabricated for this purpose and measurements noted. Details are tabulated below:

Sl. No	Dumper No.	Initial hour meter reading hrs.	Final hour meter reading hrs	Drop in oil level in fuel tank mm
1	3	1012.50	1015.00	31

Dumper operation time = 2.5 hrs

Fuel consumption = 13.1 ltrs

Fuel consumption / hour = 5.24 l/h

The dip stick readings in the fuel tank were taken on fairly level ground on the mines face as well as at the maintenance workshop. The ground was not flat, but generally level. The fuel consumption figure derived as above is much lower than the computed figures noted in the log book.

This finding justifies a detailed investigation into fuel consumption characteristics of all the dumpers, and other Diesel driven machinery from time to time by plant management.

Assuming a tolerance for the ground condition and allowing an allowance of 50%., the fuel consumption figure is

$$5.24 \times 1.50 = 7.86 \text{ l/h}$$

The present fuel consumption of Dumper 3 (as per stores data) is 14.36 l/h.

Hence saving achieved is

$$\frac{14.36 - 7.86}{14.36} \times 100 = 45.26\%$$

Similar exercises conducted on all the dumpers, loaders ripper/dozers may yield an all round saving of average 12%.

Hence saving of HSD fuel oil across the board for diesel driven mobile mining machinery could be approx. 72,294 l/y based on one shift operation.

Annual potential energy savings of HSD fuel oil	=	72,294 ltrs
Annual value of savings	=	Rs. 6,50,646/-
Cost of Implementation	=	Negligible
Simple payback period	=	Immediate

6.3 RECOMMENDATIONS

A. Dust control and Air quality maintenance are important. The crushing and screening plant should be provided with Air pollution and dust collection equipment, so that engine oil filters and air filters are kept clean and the machinery environment is conducive for clean operation.

B Majority of dumpers are having fuel oil tank and pipeline leakages and the same should be rectified

C Oil level indicators provided in the dumpers' fuel tanks should be cleaned, serviced and made operational. Direct dip stick readings on flat ground will give more accurate measurements of fuel consumption.

6.4 SUMMARY OF POTENTIAL SAVINGS

Sl. No	Proposal	Annual Energy Savings			Cost of implementation Rs.	Simple payback period Years
		Elec. kWh	HSD Ltrs.	Cost Rs.		
1	Generator Driven from engine power take off	1,18,440		3,90,852	2,25,000	0.58
2	Accurate Fuel Measurement & Leakage control		72294	650646	Negligible	Immediate
	Total	1,18,440	72294	1041498	2,25,000	

7.0 HOT AIR GENERATOR (KAOLIN PLANT)

7.1 FACILITY DESCRIPTION

A study was conducted to assess the thermal status of the hot air generator in the Kaolin plant.

The process flow chart of the Kaolin plant is given in Appendix - 7/1.

The hot air generator plays a key role in the Kaolin process plant. It consists of a combustion chamber fired by an oil fired burner which transfers heat to air supplied by a centrifugal fan. The heated air leaves the chamber at 206 to 209 °C and enters the swirl drier. It leaves the drier at 92 °C before entering the cyclone and bag filter. The effectiveness of the swirl drier is dependent on the moisture content of the filter cake supplied by the screw feeder in to the drier. Although the drier and plant are designed for productivity at a filter cake moisture content of 30% many a time the moisture content exceeds 70% resulting in excessive process time in the drier and consequent delay in production time and drop in output. It is imperative that the filter cake moisture is controlled within permitted limits.

7.1 ENERGY BALANCE

An energy balance of the hot air generator was conducted and the summary is tabulated below :

Particulars	kcal	Percentage
Heat Input		
By fuel	211680	100
Heat Output		
a. Surface heat loss	32317.7	15.30
b. Heat loss due to leakages	401.8	0.19
c. Heat loss in exhaust gas	26012	12.30
d. Hot air generation + Unaccounted losses	152948.5	72.2[illegible]

It is observed that the surface heat loss due to uninsulated shell and heat loss due to leakages in the burner end and rear end of the shell could be avoided and mitigated by insulation and mechanical rectification work. This would enhance the thermal efficiency of the hot air generator.

7.2 WASTE HEAT RECOVERY

At present cold air at ambient temperature is being supplied to the combustion system. Since the exhaust gas from the hot air generator is leaving at 204 °C, it is suggested that a preheating operation be conducted on the combustion air before it enters the burner. A simple insulated duct work could be constructed to divert the hot exhaust air around the combustion air before reaching the chimney. By this the temperature of the combustion air could be increased to 95 °C, and thus achieving 2891 l/y of HSD fuel oil saving.

7.3 RECOMMENDATIONS

A. The outside shell of the hot air generator should be insulated. The insulation materials are all available at the plant site already supplied by the equipment supplier. Proper insulation of the shell will achieve HSD fuel oil savings as explained in Appendix - 7/2.

B. The top portion of the swirl dryer is not insulated. The same should be insulated at the earliest, since all insulation materials are available at site.

C. There is considerable heat loss from openings between flanges and joint plates in the burner side end of the hot air generator. Losses are also present at the joints at the opposite end. Rectification of these leaks will save HSD fuel oil as explained in Appendix - 7/3.

D. A fair amount of heat is being taken away by the hot exhaust gas through the chimney. This gas could be used for preheating the combustion air being supplied to the burner. By preheating the combustion air, HSD fuel oil could be saved as explained in Appendix - 7/6.

The heat loss calculation details are highlighted in Appendix 7/4.

E. The burner combustion air supply line has a damper for flow control. The following observations were made of the CO_2 percentage and exhaust gas temperature at different damper positions. The same could be discussed with the equipment supplier to ascertain combustion efficiency and percentage of CO_2 optimisation.

Sl. No.	Damper Position	Exhaust Gas	
		% CO_2	Temperature °C
1.	30°	6	204
2.	20°	6.5	218
3.	45°	4.5	208
4.	30°	6.5	221

7.4 SUMMARY OF POTENTIAL SAVINGS

Sl. No.	Proposal	Annual Savings HSD		Cost of Implementation	Simple payback period
		l/yr	Rs./yr	Rs.	Years
1.	Rectifying heat loss from uninsulated shell	8190	73710	Nil	Immediate
2.	Rectifying heat loss from leakages in shell	120	1080	Nil	Immediate
3.	Recovery of waste heat in exhaust gas to preheat combustion air	2891	26019	75,000	2.88
	TOTAL	**11,201**	**1,00,809**	**75,000**	-

Area	Connected kW*
Township	105
Street Light	8.4
Factory Lighting	30
Unloading Station Lohardaga	3.5

* Includes load estimates of fans and other office equipments

8.2 OBSERVATION, ANALYSIS & FINDINGS

A. General

The details of measured lighting levels are included in Appendix-8/3. The observations regarding lighting load parameters are given below:-

☞ The plant has already installed manual voltage regulator of 67kVA rating, set to give 400 volts output. This is a good measure.

☞ Except in the administrative block, where fluorescent lamps are fitted for lighting, mercury and sodium vapour lamps are used, every where in the plant. This measure is good since HPSV lamps give higher lumens/watt.

☞ The fans, air conditioners and other office equipment loads are connected in the lighting circuit itself which should be isolated from lighting loads.

8.0 LIGHTING SYSTEM

The plant can be broadly classified into the following areas for the purpose of the lighting system study.

- Factory Sheds, Mines & Offices
- Security and Street Lighting
- Township - Residential
- Unloading Station - Lohardaga

The total connected lighting load is approximately 150kW (including fans, air cooler etc.,). The study covers :

⇨ Measurement and analysis of lux levels in the factory and mines area.

⇨ Lighting load measurements and review of energy efficient lighting system

⇨ Effective house keeping measures.

Details of lighting systems/luminaires employed in Township are given in Appendix -8/1 and connected load details are given in Appendix - 8/2.

8.1 FACILITY DESCRIPTION

The plant has made extensive use of fluorescent, incandescent and HPMV / HPSV lamps in different areas. The plant layout and design has taken care to use natural light to a considerable extent. An effort has been made to quantify the total connected lighting load and the details are given below:

- Operating load of lighting systems is typically 50-60 kW at present, contribute to 15%-18% of total energy consumption. However, from the utilisation point of view, it has been observed that the lighting levels measured are not adequate at some of the places. The area wise analysis and observations are presented in the following sections.

- Loading on the LDB main panel to township should be balanced, by reviewing the circuit, so that the load on all the 3 phases are balanced. As a result the neutral current will be reduced and burning out of lamps because of neutral line open circuit can be avoided. Detailed of measurements carried out during morning and evening periods are given in Appendix-8/4.

B. Observations on Illumination

i. Township

Power measurements have been carried out on various lighting feeders of township to assess the system lighting load. Details of measurements are given in Appendix - 8/4. The factory lighting load is tapped from existing power panels in various sheds and hence, these are not indicated here.

The voltage level is between 229-240V and pf is observed to be above 0.94. The neutral current is observed to be on higher side in some of the feeders which indicates the unbalanced load on township feeders. Lowering of voltage levels to 215 volts is expected yield energy savings.

The township lighting is adequate, however, there are certain dark patches. Illumination at 'D' type quarters can be improved by replacing 125W MV lamps with 70W SV lamps. Illumination levels at bus parking area and in front of office main gate should be improved further.

ii. Mines and Offices

The illumination levels are satisfactory at offices and workshop. However use of incandescent lamps should be stopped and plant should propose to use 1 X 40W fluorescent fittings in most of the places. Areas where 1 X 125W MV lamps are in use have been identified and it is recommended to replace these fittings by 1 X 70W HPSV fittings for efficient illumination. The illumination levels in crusher and pulveriser area are not adequate. Dark patches on road junctions and operating areas have been identified (in Appendix -8/3 for improving illumination).

Iii. Street Lighting Systems

Street Lighting is adequate for the main office and township areas. However use of 70W HPSV should be standardised in place of 125 HPMV lamps. Plant management has already initiated steps to install 25 nos. of HPSV lamps at various locations for street lighting. HPSV lamps offer good visibility and spread for the height of pole available in township. The street lighting in township has 32 nos. of 125W HPMV fittings which could be replaced with 70W HPSV fittings in a phased manner. This has an estimated annual energy saving potential of 8250kWh, with an investment of Rs. 80,000/- giving payback of 2.9 years.

Inadequacies in street lighting for roads leading to and from mines/ ropeway areas are highlighted in Appendix - 8/3 (page 4). This is an important measure that plant management should initiate for implementation from view point of safety to plant personnel. Most of the road junctions do not have any illumination.

C. Replacement of Incandescent Lamps with Fluorescent Lamps

Plant has extensively made use of incandescent lamps in various production and plant areas. It is recommended to replace incandescent lamps of 100W and 200W in plant and township areas by 40W fluorescent fittings. It is suggested to de-codify stock of incandescent bulbs in a phased manner, so that fittings with higher lumens/watt are employed in the plant.

Details are worked out for such replacement option proposed for production and township areas in Appendix -8/5. The potential energy savings is to an extent of 6204 kWh per annum with an investment of Rs. 6,000/- for 15 nos. single/double tube fittings. The implementation of above measure is expected to payback in 6 months. Details are given in Appendix - 8/5.

D. Replacement of Incandescent Lamps by Compact Fluorescent Lamps (CFL)

It is observed that 100W incandescent lamps are used at corridor, entrance of offices and guest house. These are not energy efficient giving low lumens/Watt. It is proposed to install compact fluorescent lamps of 15W and 25W for these areas. The cost of implementation for 6 nos. of CFL's work out to Rs. 2,600/- replacing 6 X 100W bulbs. The annual energy savings work out to 1902 kWh and the investment is expected to payback in half year. Details are given in Appendix - 8/6.

Plant management should propose to implement this measure in such areas like corridors, passages, toilets, stores, especially in new projects/buildings.

E. Replacement of Incandescent and 125W HPMV lamps by HPSV lamps in Plant Locations

It is proposed to replace 150W/200W incandescent lamps and 125 HPMV fittings by 70W HPSV fittings for improved illumination. The incandescent lamps and HPMV lamps installed for outdoor building lights should be replaced in areas given in Appendix - 8/7.

The above proposal is expected to yield energy savings of 2812 kWh. The estimated cost of implementation for 15 nos. of 70W HPSV fittings will be Rs. 27,500/- giving a payback of 3 years.

F. Switching off 3 nos. of 70W HPSV Lamps in club premises

Club house has 4 nos. of 70W HPSV lamps installed for area lighting on the building. These fittings were observed to kept switched 'ON' even after 10.00 p.m. For security and road lighting, one fitting may be kept in line, so that the other three fittings could be put off through a timer after 10.00 p.m.

It is proposed to install a timer and contactor costing Rs. 2,500/- , so that effective timer control system could be programmed yielding energy savings.

Annual energy savings	=	(3X0.07)X365X7hrs
@ 7hrs/day switch off period	=	536 kWh
Cost of implementation	=	Rs. 2,500/-
Simple payback period	=	1.4 years.

Similar arrangement is recommended for lights installed at mines manager's bungalows and other remote area security lights.

8.3 SOLAR STREET LIGHTING SYSTEMS

It is economical to install solar Photo-voltaic street lighting for areas where power supply has to be drawn to considerable lengths involving expenditure towards cable, switches and problems of voltage drop.

The plant has been experiencing severe power failures which amounts for about 900 interruptions in 1996, when DG supply was extended to plant and township loads. During such changeover periods involving two interruptions for 2 - 3 minutes each. Several areas will be dark which is necessary that alternate lighting systems are available, from view point of safety and security.

Hence it is recommended to install centralised solar street lighting systems instead of standard emergency lights. These could be utilised as standard lighting systems independent of DG or grid supply which will act as emergency lights during power failure/changeover periods. The existing fittings could be used elsewhere after installing solar photo-voltaic lighting system.

The following locations have been identified for installations of one fitting each (15 nos.)

- Main gate, Office entrance, garage entrance and inside
- Guest house, Main bus parking yard,
- DG power house / pump house
- Kaolin plant
- Crusher 1/2, Ropeway,
- Pulveriser 1 / 2, DG (Hired)

The above systems are expected to cost about Rs. 3.0 lakhs and Plant management should propose this scheme in phases.

8.4 POINTS FOR UPGRADING ENERGY EFFICIENCY IN LIGHTING INSTALLATIONS

- The lighting, fan and air-conditioning loads should be wired up separately, so that the control and programmes of switching can be initiated.

- Programmable day week dial timers should be incorporated in lighting circuit

- Compact fluorescent lamps should be used for all corridors, toilets, walkways, office/executive table lamps, display rooms, machine inspection lamp etc.,

- Occupancy sensor to be used for office/room lighting

- Metering of lighting consumption should be carried out

- Regularly monitor the voltage levels of lighting load and reduce voltage of operation

- Always fluorescent fittings with electronic chokes as original equipment should be installed.

- Monitor failure rate of chokes and bulbs month-wise and analyse failure data from company past records.

- Install key socket switches for office rooms/stores which are occupied intermittently.

8.5 GENERAL MAINTENANCE PRACTICES

i. The luminaires should be properly maintained. The sky lights are to be provided for sheds, so that illumination during day time can be avoided.

ii. Lux level in certain areas can be improved by adopting simple measures such as; changing reflector/acrylic covers and regular maintenance schedule.

8.6 RECOMMENDATIONS

A. Replacement of 12W HPMV lamps by 70W HPSV Lamps

The street lighting in township has 32 nos. of 125W HPMV fittings, which could be replaced with 70W HPSV fittings in a phased manner. This measure is expected to yield energy savings as given below with additional benefits of improved visibility and spread of the light.

Annual energy savings	=	8250 kWh
Annual Cost of energy savings	=	Rs. 27,225/-
Annual cost of Investment	=	Rs. 80,000/-
Simple payback period	=	2.9 years

B Replacement of Incandescent Lamps with Fluorescent Lamps

The incandescent lamps of 100W and 200W which are used extensively in the plant should be replaced by 40W fluorescent tube lights. The details of replacement option for production and township areas are given in Appendix - 8/5.

Annual energy savings	=	6204 kWh
Annual Cost of energy savings	=	Rs. 20,470/-
Annual cost of Investment	=	Rs. 6,000/-
Simple payback period	=	0.3 years

C Replacement of Incandescent Lamps by energy efficient by compact fluorescent lamps (CFL)

The existing 100W incandescent lamps at corridors, entrance of offices and guest house should be replaced by CFL's of 15W or 25W. The techno-economic details of installing 6 nos. of CFL's are given in Appendix-8/6.

Annual energy savings	=	1902 kWh
Annual Cost of energy savings	=	Rs. 6,276/-
Annual cost of Investment	=	Rs. 2,600/-
Simple payback period	=	< ½ year

D Replacement of Incandescent and HPMV Lamps by HPSV Lamps

The incandescent lamps and HPMV lamps installed for outdoor building lighting should be replaced by 70W HPSV lamps.

This measure is expected to yield annual energy savings as mentioned below(Ref. Appendix - 8/7).

Annual energy savings	=	2812 kWh
Annual Cost of energy savings	=	Rs. 9,280/-
Annual cost of Investment	=	Rs. 27,500/-
Simple payback period	=	3.0 years

E Use of Timer for Effective Control and Switching for sports club

A timer should be installed for switching 'off; the 3 nos. of 70W HPSV lamps in the club house. (Ref. Section 8.2 (F) for details)

Annual energy savings	=	536 kWh
Annual Cost of energy savings	=	Rs. 1,769/-
Annual cost of Investment	=	Rs. 2,500/-
Simple payback period	=	1.4 years

F Installation of Solar Photo-voltaic System for Street Lighting

It is economical to install solar photo-voltaic system for street lighting, where power supply has to be drawn to considerable lengths. This system is also proposed for emergency lighting system at considering safety and security aspects. The system is expected to cost about Rs. 3.0 lakhs for 15 nos. of stand alone solar street lighting systems. . The details are presented in section 8.3 and addresses are given chapter Retrofits.

8.7 SUMMARY OF POTENTIAL SAVINGS

Sl. No	Proposal	Annual Savings		Cost of implementation Rs.	Simple payback period Years
		Energy(kWh)	Cost (Rs.)		
1	Replacement of 12W HPMV lamps by 70W HPSV Lamps	8250	27225	80000	2.9
2	Replacement of incandescent lamps with 40W fluorescent lamps	6200	20470	6000	0.3
3	Replacement of incandescent and HPMV lamps by HPSV lamps	2812	9280	27500	3.0
4	Use of timer for effective control and switching for sports club	536	1769	2500	1.4
	Total	17798	58744	116000	1.97

9.0 SOLAR WATER HEATING SYSTEMS

Hot water is in continuous demand in the residential quarters and guest house. The present method is to use 1.5 kW electrical geysers located in individual houses and buildings. To bring down the electrical kW demand and load on the DG sets during peak period, alternative sources of hot water generation were examined.

- By recovering waste heat from the DG set Exhaust Gases, 40,000 ltrs of hot water per year at 50°C could be generated. This has been discussed in detail in Chapter- 4.3 C.
- Solar water heating system could be installed. The hot water output from the solar heater could be fixed as inlet to the geyser, so that when the sun is hot and bright, hot water is produced and it runs through the geyser which is in 'OFF' condition.

- During rainy and cloudy days, the solar heater will not be effective and so the cold water from the solar heater will run through the geyser and become hot water when the geyser is 'ON'.

Solar water heating systems could be installed as follows:-

Sl. No	Area/Block	Existing geysers*	Capacity in LPD	Remarks
1	Mines Manager's residence	2	100	The hot water from the solar water heating outlet to be directly coupled as raw water inlet to geyser
2	Guest house Indal house	2	200	
	'C' Type	1	100	
3	Engineers Mess	4	4 X 100	
4	Medical Centre	1	100	

.ocation of other 3 other geysers should be examined.

The load of 10 geysers amounting to approximately 15 kW can be spared during peak loading period. Considering 3 hrs/day operation of geysers at the above locations the energy saving potential is 16,400 kWh/annum. (Rs.54,200/-per annum)

The budgetary investment will be Rs. 1.50 lakhs giving payback of 3 years. However implementation of the above measure is expected to bring down the loading of DG during power failures and peak load periods of plant. Opêration of additional DG during peak loads can be avoided since this proposal is one of peak shaving, on load.

The above investment will attract Govt. of India and IREDA subsidies and incentives namely accelerated depreciation, outright subsidy etc. This will substantially reduce the simple payback period and make this investment economically viable.

10.0 ENERGY MANAGEMENT

10.1 INTRODUCTION

Energy Management is a continuous process. It involves not only identifying energy saving opportunities, but also evolving plans, strategies and organisation for sustained implementation and achieving progressively improved results. The energy management programme should begin with the analysis like :

- Ø Consumption of different forms of energy
- Ø Energy cost as a percent of total production cost
- Ø Major energy consuming equipments and their diversity.
- Ø Potential savings and its comparison with current profits
- Ø Estimate of cost of additional metering that may be required
- Ø Within the existing Company, how best can energy consumption be monitored in different areas (or) departments.

10.2 ENERGY MANAGEMENT PROCESS/STRATEGY

There are four distinct stages :

- ☞ Defining energy accounting centres
- ☞ Measurement
- ☞ Analysis and monitoring
- ☞ Targeting

A. Energy Accounting Centres (EAC)

The first step in installing an energy management programme is to identify along the energy flow paths of the plant, a series of 'Energy Accounting Centres' which will provide the requisite break-down and frame work necessary, both for monitoring energy performance and for achieving targets. An Energy Accountable Centre might consist of individual equipments, section/department or even a whole building.

B. Measurement

Before any resource can be managed effectively, it must be measured correctly, in order. to provide the information upon which to base management decision. So like all truly effective management systems, energy management depends on the collection of relevant data upon which to judge current performance and to plan for future improvements. The consumption figures should be collected by major equipments/section-wise. There should be a reliable, effective and comprehensive metering facility to show the energy consumption by each major energy using points/ equipments. These meters have to be regularly maintained to keep them in working condition. The gathering of this information forms an essential part of the monitoring programme. It is important that the information obtained should be reasonably accurate and that the monitoring process tied in with other review procedures, such as monthly financial and production figures, so that information on energy flows can be meaningfully related to other performance data.

C. Analysis and Monitoring

After collection of energy consumption and cost data, the next stage is to use that information to analyse and evaluate performance.

Analysis and evaluation involve, regularly comparing actual levels of energy consumption with the amount of energy expected to be used as defined by a set of internally based standards. Difference between actual consumption and these standards will reveal either improvements in energy efficiency or a fall-off in performance levels. In this way, the information produced by monitoring forms a basis for continuing performance evaluation and control.

On the one hand, it will provide quantified evidence of exactly how successful have been the measures to improve performance. On the other, it will indicate if and where failure have occurred and trigger the necessary remedial action.

Analysis should be a continuing process so that action can be taken speedily if energy efficiency deteriorates.

D. Targeting

The first stage in the process of setting targets is to carry out energy audit - a procedure which can, with advantage, be repeated every year. An energy audit will identify the possible range of energy efficiency improvement measures available and appropriate to the circumstances of an individual organisation. It will also provide an estimate of the cost and the likely return on investment.

From the results of the audit, management can select a series of measures to form an action programme - starting with the most cost-effective and taking into account, for e.g. the availability of capital and effect of the measures on the organisation's other activities.

11.0 CHECKLIST FOR EFFICIENT REWINDING PRACTICE

INTRODUCTION

When a motor fails, the user is often faced with deciding whether to rebuild or replace it. Rewinding, usually entails a lower initial cost compared to cost of replacement especially, for larger motors.

Rewinding can preserve and in rare cases, slightly improve motor efficiency if skilfully done. However, the rewinding process provides many areas by which the motor efficiency can be degraded, greatly increasing operating cost and energy consumption. To ensure the hightest quality in repaired motors, the consistent use of test equipment and documentation procedures must be integral parts of the repair process, so that the quality of its components can be visited before the motor is put back to servile.

HIGHLIGHTS BEFORE DISCUSSION

It is technically possible to rebuild motors to match or exceed their original efficiency, but typical rewinds reduce motor efficiency by about one percentage point.

Motor users are frequently faced with a decision to repair a failed standard efficiency motor or replace it with a new, energy efficient motor. The economics of a rewind versus replace decision should not be based simply on a comparison of nameplate data for the two motors. The old motor is likely to operate below nameplate efficiency, because of ageing and damage from past or proposed rewinds. Moreover, if the old motor was oversized, as is often the case, the new replacement can be smaller, thus cutting capital cost. Energy efficient motors also tend to last longer. When these factors are considered, it often makes economic sense to replace failed standard efficiency motors with high-efficiency units instead of rewinding them.

Rewinding is often more cost-effective if one or more of the following conditions hold; the motor is larger than 125 hp, it operates less than 2,000 hours per year, it is already very efficient so little improvement is to be gained by replacing it, it is a speciality design for which high-efficiency replacements are unavailable, and the price of electricity is low.

The motor repair industry and some utilities are collaborating to develop quality standards, testing, and training in proper motor rewind practice so that motor efficiency is maintained or improved whenever possible.

Improved motor repair practice is crucial if utilities and end users are to protect their investment in energy efficient motors that will someday fail and need repair.

MOTOR REWINDING PRACTICE - CHECKLIST

		YES	NO.
I	**INITIAL INSPECTION SCHEDULE**		
a)	Overall damage and recording of findings given as a damage report		
b)	Record of name plate data, application details, past history given by the sender		
c)	Pre-repair motor tests carried out and recorded the pre-repair motor test condition.		
II	**DOCUMENTATION OF COMPONENT CONFIGURATION**		
a)	Winding sketch made for the type and configuration of end connection		
b)	Condition of shaft checked, like run out/ bearings / shaft extension and compared with original data		
c)	Other data like bearing fits, commutator dia, brush length brackets checked.		
c)	All components physically inspected for looseness, missing parts, (cracks or signs of wear), clogged vent passages, discoloration, charring, corrosion/moisture or oil inside machine		
IV	**ELECTRICAL DAMAGE APPRAISAL**		
a)	Megohm test carried out to determine the insulation between windings and ground		
b)	Single phase test performed to test any broken or loose rotor bars (with motor assembled) or a grower test carried out with the rotor removed		
c)	If the above tests are positive, is it advisable to rewind		
V	**MECHANICAL DAMAGE APPRAISAL**		
a)	Are original equipment spares available to replace the parts identified.		

YES NO

VI RECONDITIONING WITHOUT REPAIR

If the motor has passed all the above tests do, you still rewind, the motor, do you carryout the following

a) Cleaning/Varnishing

b) Painting of motor

VII REWINDING OF MOTORS

a) Coil removed by excessive use of heat, chemicals or mechanical force can damage stator core laminations

b) Ovens are used to preheat the core before opening the winding

c) The core is heated for three hours upto ......°C in ovens. This softens the varnish enough to enable removal of winding — 150 200 250

d) Burning the core before winding removal will increase core loss.

e) Excessive heat will damage insulation between laminations and increase core loss. Exceeding this, will result in maximum temperature raise, degrading performance and can lead to premature failure of windings.

f) Eddy current losses will........ from above (c) — Decrease Increase

g) Strong chemical agents are used to remove windings, varnish sticking to cores — Decrease Increase

VIII CORE DAMAGES

a) IF core damage is proved, the client (user) is informed that rewinding is not economical

b) One point efficiency drop, adds electricity costs of 1/10th motor purchase cost

AGREED NOT AGREED

c Core less can get doubled and any 40 kW motor with 1kW coreloss, can have 14°C additional temperature raise if core is not good. Do you agree that the above will reduce insulation life by 38% and life of grease by 31%

IX POTENTIAL FOR IMPROVED PERFORMANCE YES NO

AFTER REWINDING

a) Replacing aluminium winding with copper increases efficiency

b) Packing more copper into slots yield lower copperloss, lower coil resistance and higher efficiency

c) Checking on previous rewind for gauge/no. of turns and ensuring and the original value improves efficiency. Could it be.

d) By rearranging the core stacks of a damaged core, corelosses can be reduced

e) Record of No. of load current maintained and compared with standard manufacturers data. (Test carried out at rated voltage)

f) Dynamometer test carried out and certified (Not always)

g) Loop test carried out for identifying hot spot in core

h) Loop test is quite unsophisticated, however can detect hotsopts but can not detect damage to back iron core teeth.

X IMPACT OF REWINDING ON EFFICIENCY

AGREED NOT AGREED

a) G.E.Co. tests indicated that after rewinding corelosses increase by 32% and efficiency dropped by 0.5 - 1%.

YES NO

b) Full load efficiency after a rewind dropped by a range of 1.5 - 2.5% point.

c) Due to wrong setting of oven temperature to remove windings, measured core iron losses have declared efficiency drop of 0.5 - 2.5% points after 5 rewinds.

XI AVERAGE LIFE TIME OF MOTORS AT FULL LOAD AFTER SURVEY

Motor size (HP)	Lifetime Hours	Agreed	Not agreed
<	2,770		
1 - 5	5,000		
5.1 - 20	17,000		
21 - 50	37,000		
51 - 125	80,000		
> 125	90,000		

GUIDELINES FOR MAINTAINING MOTOR EFFICIENCY DURING REWINDING / REBUILDING USEFUL LIST OF DO'S & DONT'S

	Do	Don't
01.	Conduct a stator core loss test before and after stripping.	Heat stators above 650 degree F (350 degree C) (Presumably this is recommended oven) setpoint, not the recommended maximum temperature experienced by the stator. Even if it is an oven setpoint guideline, this could be too high a setting to avoid damage to some motors as discussed above.
02.	Repair or replace defective laminations.	Sandblast the core iron
03.	Calibrate all test equipment and measuring devices atleast annually against standards.	Knurl, peen, or paint bearing fits.
04.	Measure and record winding resistance and room temperature.	Use an open flame for stripping.
05.	Measure and record no-load amps and voltage during the final test.	Grind the laminations or file the slots.
06.	Have a quality assurance program.	Increase the air gap
07.	Have and use, at a minimum, the following test equipment; ammeter, voltmeter, wattmeter, ohmmeter, megohmmeter, high potential tester.	Increase the resistance of the stator windings
08.	Have a three-phase power supply for running motors at rated voltage. (Oil immersed auto transformer of 40 to 100 Amps)	Make mechanical modifications without the customer's prior approval. This includes but is not limited to changing fans, types of bearings, shaft material, and seals.
09.	Balance the rotor	Change the winding design.

HIGHLIGHTS OF REWINDING POLICY OF A COMPANY

While many companies rewind most failed motors over 10 HP, the Southwire Company one of the largest wire and cable manufacturers in the U.S., rewinds virtually no motors below 125 HP and has a policy to purchase the highest efficiency motors available. The firm's motor rewind and purchase guidelines are summarised below :

- All new motors should be energy efficient motors. Table in next page shows Southwire's minimum efficiency standards for new motors.
- Replace rather than rewind standard AC motor upto 125 hp when new energy efficient motors are available. Above 125 hp, an individual evaluation should be made to determine if the difference between rewinding and purchasing a new energy efficient motor can be recovered in five years/
- When energy efficient motors fail, rewind them for a cost of upto 40 percent of a new motor. All rewound motors to be tested with efficiency documented.
- Insist rewind shops to have temperature controls on burnout furnaces.
- Improve stock of essential motors by better record keeping to determine frequently changed motors. Also motors in stock should be energy efficient.
- Target certain motors for replacement based on misapplication, good payback, or low replacement cost.

SOUTHWIRE'S MINIMUM MOTOR EFFICIENCY STANDARDS FOR NEW INDUCTION MOTORS

HP	Drip proof minimum efficiency	TEFC Minimum Efficiency
5	89.5	90.2
10	91.7	91.7
25	94.1	93.6
50	94.5	94.1
125	95.4	94.1
200	96.2	95.8

12.0 CONCLUSION

The detailed energy audit conducted in the plant covered all energy consuming areas both thermal and electrical. It is estimated that there is potential to save Rs.17.50 lakhs worth of energy which forms 23.3% of the total energy cost for the year (1996). The investment required to achieve the estimated savings is Rs.11.065 lakhs.

The list of suppliers for the retrofits that have been recommended is given in Appendix - 12/1.

ACKNOWLEDGMENT

We would like to place on record our sincere thanks to Mr. Avijit Ghosh, Mines Manager, Mr. D. Mallick, Supterintendent - Maintenance, Mr. R. Burman, Mechanical Engineer, Mr. R. K. Prasad, Electrical Engineer, Mr. Sharma (Pulveriser Dept.), Mr. Sinha (Electrical Maintenance) and all other engineers and staff for their involvement and co-operation extended to the study team.

APPENDICES

DEPARTMENTWISE - ENERGY CONSUMPTION SUPPLY & CONSUMPTION DETAILS

Month	Total power consn.	Source of Power					Unit Power Consumption							Maximum Demand	Power Factor
		B.S.E.B.	Own Generation		Hired D.G.Set		Mines	PV. BX	Kaolin	Pump	Colony	Misc.	Total	kVA	
	kWh	kWh	kWh	HSD Consmn.	kWh	HSD Consmn.	kWh	kWh	kWh	kWh	kWh	kWh	kWh		
Jan 96	69816	59650	10166	3705	-	-	8915	10160	13273	8828	20908	7731	69815	209	0.947
Feb 96	50273	37786	12487	4910	-	-	7686	7120	4796	N A.	17552	5799	42953	183	0.932
Mar 96	55631	29066	26565	10760	-	-	7680	9700	9529	3240	17500	6866	54515	181	0.955
Apr 96	53187	39506	13681	5365	-	-	7850	5720	12414	3140	16631	5939	51694	183	0.95
May 96	58171	34223	20448	7950	3500	N.A.	13712	7300	8373	3420	18500	6866	58171	189	0.887
Jun 96	64246	38241	19812	6750	6193	2240	11701	16393	9004	2680	18279	6181	64238	200	0.926
Jul 96	91013	51350	33800	11970	5863	2089	11255	20163	29224	3020	20408	6943	91013	222	0.961
Aug 96	87424	44103	36313	12920	7008	3090	15320	15295	27321	2860	20306	6322	87424	207	0.953
Sep 96	71919	22063	33539	12325	16317	7160	16727	16920	10297	2860	18303	6812	71919	*	*
Oct 96	94980	43967	21573	8925	29440	11380	11539	28700	25830	3380	18954	6577	94980	*	*
Nov 96	69726	42358	12191	4390	15177	5775	15026	17520	10520	3180	16701	6809	69756	*	*
Dec 96	77388	32321	8357	3155	36710	14490	13900	34920	880	3240	17484	7067	91194	*	*

* Trivector & meter out of order. Hence average demand & energy charges are billed

TATA ENERGY RESEARCH INSTITUTE
BANGALORE

APPENDIX - 2/2

HSD CONSUMPTION PROFILE FOR THE YEAR 1996

Month	Consumption in mining equipment	Consumption In D.G.Set	HSD for hired DG sets
Jan	39791	5658	-
Feb	32828	6850	-
Mar	37602	12800	-
Apr	33013	6800	-
May	33355	10104	1904
Jun	26481	9240	2240
Jul	38240	13789	2089
Aug	43774	15498	3090
Sep	68388	19368	7160
Oct	56207	21180	11380
Nov	50257	9775	5775
Dec	61622	16890	14490

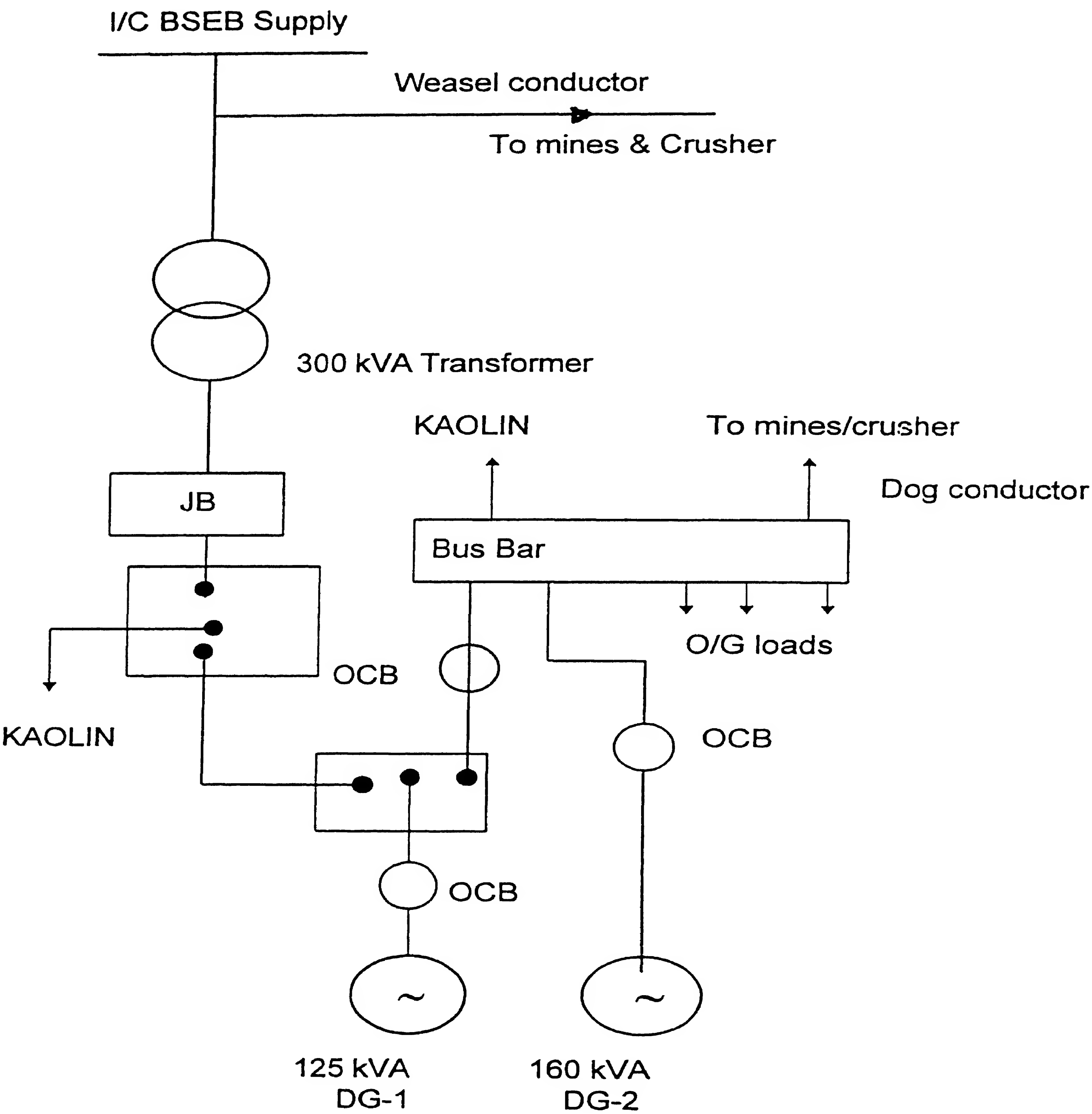
Appendix - 2/2 contd.

AVERAGE DIESEL CONSUMPTION BY MINING EQUIPMENT IN 1996

Equipment	LT/H	Equipment Description
Ripper Dozer 1	66.79	Mining
Ripper Dozer 2	86.17	Mining
CK-90 1	14.24	Loader
CK-90 2	12.86	Loader
Tata Hitachi	15.86	Loader
TEREX 1	15.12	Dumper
TEREX 2	15.19	Dumper
TEREX 3	14.36	Dumper
TEREX 4	15.19	Dumper
TEREX 5	15.94	Dumper
TEREX 6	15.16	Dumper
Crusher (large)	15.46	Jaw Crusher
Crusher (small)	12.83	Jaw Crusher

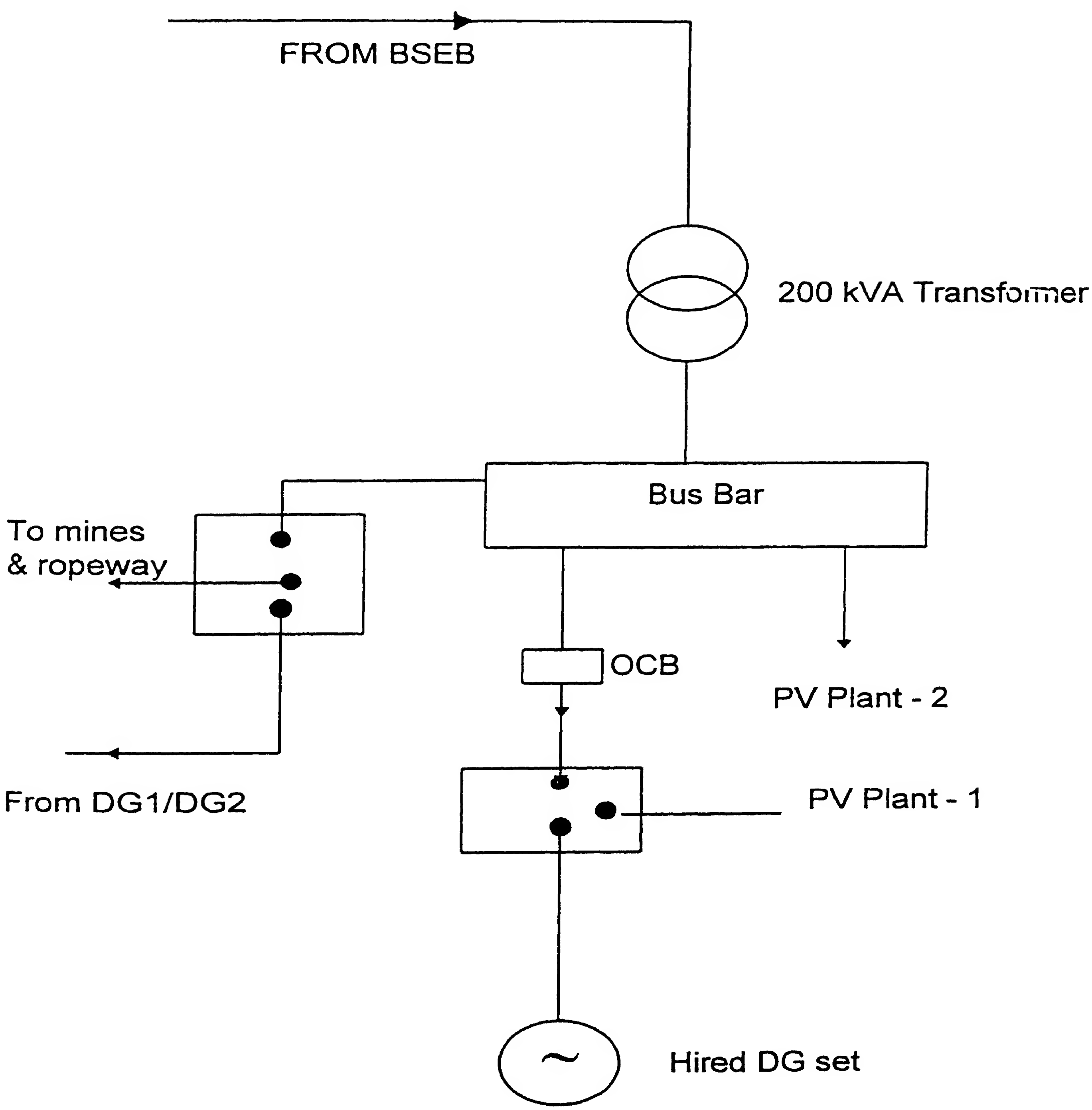
APPENDIX - 3/1

SINGLE LINE DIAGRAM OF ELECTRICITY DISTRIBUTION



Appendix - 3/1 contd.

SINGLE LINE DIAGRAM OF ELECTRICITY DISTRIBUTION



APPENDIX - 3/2

BRENT FORD - TRANSFORMER

1	kVA		- 200		
	Volts	HV	- 11000	Type of Cooling	- O.N
		LV	- 440	Frequency	- 50 Hz
	Amps	HV	- 10.5	Impedance volts	- 4.35%
		LV	- 262	Oil quantity	- 575 ltrs
	Phase	HV	- 3	wt. of oil	- 500 kg.
		LV	- 3	Cone &	- 675 kg
				Total wt.	- 1625 kg.

Vector Symbol	- Dy-11
Guaranteed max. Temp.	- 45°C
Manufacturing	- Brent Ford Electric Co. (India) Ltd. Calcutta

Appendix - 3/2 contd.

2. kVA		- 300			
High Volts	HV	- 11000	Volume of Oil	-	400 ltrs
	LV	- 433	Mass of Oil	-	355 kg
Amps	HV	- 15.7	Untaking mass	-	740 kg
	LV	- 400	Total mass	-	1515 kg
Phase	HV	- 3	wt. of oil	-	500 kg.
Cooling type		- ON HN	Sr. No.	-	12714
Frequency		- 50 Hz	Temp. Wise top toil	-	50°C
Vector group		- DYN 11	Temp. Rise average	-	55°C
Year of mfg.		- 1996			
% Of Impedance		- 3.891			

GEC Althom India
Distribution Transformer Ltd
HMT Colony
Kalamasary, Kerala

APPENDIX - 3/3

DG SETS - MONTHLY RECORD OF # HOURS OF OPERATION & POWER FAILURES

Month/ Year	DG Set -1 125kVA	DG Set -2 160 kVA	Hired DG Set 180 kVA	Total hrs.	Power Failure # of times
Jan'96	79	88		167	60
Feb	125	115		115	44
Mar	249	249		249	40
Apr	153	115		115	62
May	208	210		210	80
Jun	164	179		179	110
Jul	295	278		278	93
Aug	312	305		320	78
Sep	258	319		319	47
Oct	108	248	255(62)	250	95
Nov	62	151	203(60)	-	-
Dec	-	124	250(13)	124	85
Total	**2013**	**2381**	**705**	**2326**	**794**
Jan'97	118	224	163 (87)	324	91
Feb	114	262	57 (200)	262	90
Mar	181	211	177 (22)	392	92
Apr	326	289	150 (100)	442	82

Note:- **Figures in bracket indicates breakdown and non-availability of hired of 180 kVA DG set.**

APPENDIX - 3/4

ENERGY AND DEMAND CONSUMPTION PATTERN - MONTHWISE FOR - 1996

Month	Total power consn.	Source of Power					Maximum Demand	Power Factor
		B.S.E.B.	Own Generation		Hired D.G.Set			
	kWh	kWh	kWh	HSD Consmn.	kWh	HSD Consmn.	kVA	
Jan 96	69816	59650	10166	3705	-	-	209	0.947
Feb 96	50273	37786	12487	4910	-	-	183	0.932
Mar 96	55631	29066	26565	10760	-	-	181	0.955
Apr 96	53187	39506	13681	5365	-	-	183	0.95
May 96	58171	34223	20448	7950	3500	N.A.	189	0.887
Jun 96	64246	38241	19812	6750	6193	2240	200	0.926
Jul 96	91013	51350	33800	11970	5863	2089	222	0.961
Aug 96	87424	44103	36313	12920	7008	3090	207	0.953
Sep 96	71919	22063	33539	12325	16317	7160	*	*
Oct 96	94980	43967	21573	8925	29440	11380	*	*
Nov 96	69726	42358	12191	4390	15177	5775	*	*
Dec 96	77388	32321	8357	3155	36710	14490	*	*

* Trivector & meter out of order. Hence average demand & energy charges are billed

APPENDIX - 3/5

LOADING PARAMETERS OF VARIOUS PRODUCTION CENTRES

Data	Amps	pf	kVA	kW	Remarks
Motive load	377	0.70	259.9	182.6	Total loads of all drives of plant
Lighting load	92 57	0.96 0.96	57.0 38.4	54.0 38.3	03/04/97 - 19.30 hrs 04.05.97 - 7.30 hrs
Max load	469	0.80	313.9	236.6	-
Avg. load	434	0.85	298.3	220.9	-

Incomer	Connected HP	A	kVA	kW
Kaolin plant	113	94.5	71.8	49.6
Water Pumping System	27.5	43.2	27.4	23.5
Pulveriser 1 & 2	127	138	82.8	64.4
Crusher-1	45	36.6	26.5	11.7
Crusher-2	40	49	26	16.5
Roperway	25	21	15.9	10.8
Colony	250 (max)	92	57.3	54

LOAD PARAMETERS ON B.S.E.B. INCOMING FEEDER

DATE : 4th MAY 1997

TIME (hours)	Voltage Line- Line V	Current I L A	POWER FACTOR	kVA	kW	kVAr	kWh	kVArh	REMARKS
21:00	405	108	0.88	76.1	67.2	35.8	199.4	132.6	
21:30	388	89.6	0.93	60.2	56.1	21.9	215.8	133.2	25- 35% current unbalance
22:00	402	112	0.9	78.1	70.2	34.2	266.8	163.7	
22:30	399	102	0.89	70.5	62.7	32.2	300.7	180.6	
23:00	411	52.3	0.94	37.2	35.1	12.4	310.7	184.2	
23:30	429	47.4	0.93	35.2	32.9	12.7	335.8	193.4	
0:00	429	48.8	0.94	36.2	34	12.7	352.5	199.7	
0:30	423	43.1	0.93	31.6	29.3	11.9	360.4	202.7	
1:00	434	42	0.93	32.1	29.8	12.2	383.3	212	
1:30	431	43.8	0.92	33.2	30.6	13	398.4	218.2	
2:00	436	43.3	0.92	32.7	30.1	12.7	413.6	224.7	
2:30	439	45.2	0.93	34.4	31.9	12.8	429.4	231.3	
3:00	441	43.9	0.92	33.5	30.9	13.1	445	237.9	
3:30	436	78.6	0.85	59.3	50.6	30.9	461	244.6	
4:00	433	75.8	0.86	56.9	48.7	29.4	485.3	259.4	
4:30	428	75.5	0.87	56	48.4	28.1	510	274	
5:00	422	46.9	0.96	34.2	32.7	10	533	285.7	
5:30	411	56.6	0.92	40.3	37.1	15.7	550.9	291.6	
6.00	408	112	0.85	79.2	67.6	41.2	578.5	305.9	
6:30	416	119	0.84	84.4	71.1	45.4	593.8	314.1	
7:00	407	98.3	0.9	69.2	62.1	30.5	639.4	337.6	
7:30	400	90.2	0.89	62.4	55.7	28.2	669.4	352.1	
8:00	414	92.5	0.87	66.3	57.7	32.7	711	374	
8:30	417	96	0.87	69.3	60.4	33.8	725.3	382.2	
9:00	398	156	0.84	108	90.5	58.4	767.2	408.5	
9:30	402	169	0.85	117	99.4	62.5	791.2	423.8	
10:00	386	181	0.86	121	104	61.1	816.8	439.3	

LOAD ON 300 kVA TRANSFORMER

DATE : 04.05.97 **BSEB INCOMER**

Time	V	I	kW	PF	kVA	kVAr	kWh	kVArh
10.00	403.00	179.00	105.00	0.84	125.00	66.90	71.78	45.12
10.10	407.00	180.00	106.00	0.84	127.00	69.90	76.79	48.34
10.30	410.00	187.00	111.00	0.84	133.00	72.60	94.62	59.85
11.00	408.00	203.00	120.00	0.84	143.00	77.20	108.46	68.70
11.20	407.00	205.00	120.00	0.83	145.00	80.60	127.79	81.00
11.30	413.00	183.00	104.00	0.79	131.00	79.90	135.22	86.15
11.40	415.00	179.00	105.00	0.82	129.00	73.90	137.02	87.45
11.50	415.00	191.00	112.00	0.81	137.00	80.20	154.11	99.17

Note : Vz = 55 when power of 31.5V - Phase - V

LOAD ON 200 kVA TRANSFORMER

Time	V	I	kW	PF	kVA	kVAr	kWh	kVArh
DATE : 07.05.97								
12.15	413.00	54.30	33.40	0.86	38.80	19.70	24.16	16.69
12.20	407.00	63.70	40.00	0.89	44.90	20.40	25.78	17.73
12.25	414.00	65.70	41.20	0.88	47.10	22.80	28.85	19.53
12.30	418.00	80.30	30.50	0.84	36.40	19.90	29.91	20.18
12.35	414.00	37.70	19.60	0.73	27.00	18.60	32.58	21.88
12.40	413.00	75.90	48.80	0.90	54.30	23.08	34.30	22.92
12.45	419.00	42.40	23.50	0.77	30.80	19.90	40.46	26.74
12.50	420.00	47.00	27.70	0.81	34.10	20.00	44 34	29.15
12.55	417.00	55.10	34.10	0.86	39.80	20.60	46.50	30.52
12.58	410.00	54.40	32.80	0.85	38.70	20.40	47.05	30.86
13.45	414.00	48.50	28.10	0.81	34.70	20.40	57.11	37.00
13.55	412.00	62.20	38.00	0.86	44.40	23.00	58.14	38.01
14.00	414.00	52.30	31.90	0.85	37.50	19.70	63.00	40.73
14.10	414.00	45.30	26.50	0.82	32.50	18.80	67.68	43.76
14.20	413.00	62.90	40.30	0.90	45.00	20.10	74.70	48.16

Energy Saving by PF improvement of Load Feeder to 0.95 Lag
(Including Demand Savings)

Sl. No.	Feeder	Load kW	Max. kVA	pf	A	Annual Oprt. Hours	Cable Length	Cable Size (Sq. mm)	% Redn. in Amps	Compn. kVAr	Capacitor Cost Rs.	kWh loss Redn.	Cost of Energy Savings	Demand Saving kVA	Annual Saving Rs.	Payback YEARS
1	Kaolin Plant	34.8	45.9	0.72	70.0	6000	200	120	24.2	*20	6600	2290	7556	11	24892	0.27
2	Borewell Pump House	17.6	22.9	0.77	35.0	4380	300	35	18.9	10	2700	1723	5685	4	12454	0.22
3	300 kVA BSEB I/C	106.0	116.0	0.90	157.0	6000	50	150	5.3	*20	4800	566	1868	6	11393	0.42
4	PV Plant Main Panel	30.0	36.0	0.80	55.0	6000	35	150	15 8	10	3900	138	455	6	9323	0.42
5	Ropeway	20.0	25.0	0.80	25.0	6000	200	120	15 8	10	2400	200	659	4	6817	0.35
6	Crusher 1	8.0	16.0	0.50	22.0	6000	20	35	47.4	10	3300	131	432	8	12256	0.27
7	Crusher 2	24.0	36.0	0.70	52.0	6000	20	35	26.3	20	5100	463	1527	9	16306	0.31
								TOTAL		@100	28800	5510	18182	48	93439	
								Results		50	# 15000	5510	18182	24	54182	0.30

* Already procured & avialable

@ Addiitonal 50 kVAr banks are to be procured.
Eixsting banks may be shifted to load centres

Cost of capacitor banks to be procured will be Rs. 300 X 50 = 15,000/-

OPTIMISING D.G SET LOADING ON D.G -2 DURING PEAK HOUR

(By clubbing the loads of DG-1 & DG-2)

DG- LOADING DATA
DATE-03-05-97

TIME	MEASURED 3- Ph. PARAMETERS						% LOADING
	Volts	Amps	Pf.				
D.G--2	V	A	Cosϕ	kVA	kW	kVAr	
11	446	81.4	0.65	70.6	45.8	53.8	44.1
	447	87.9	0.69	75.7	51.9	55.1	47.3
	447	89.4	0.68	83.6	53.0	50.0	52.3
	447	92.3	0.58	71.3	41.4	58.1	44.6
	447	110.0	0.68	85.2	58.1	62.0	53.3
11.30	447	113.0	0.72	87.7	62.8	61.3	54.8
	447	123.0	0.71	67.3	45.2	67.3	42.1
	445	119.0	0.75	91.4	68.2	91.4	60.8
	445	87.0	0.66	67.4	44.5	50.0	42.1
12	445	90.00	0.73	69.7	50.5	48.4	43.6
D.G--1							
12.30	447	99.0	0.68	76.8	52.3	56.0	48.0
	447	93.0	0.69	72.0	49.9	52.0	45.0
13.00	445	70.0	0.72	54.0	38.5	38.0	33.8
13.10	444	70.0	0.69	55.0	37.5	40.0	34.4
13.20	444	99.0	0.68	77.0	53.0	56.0	48.1
14.40	448	91.0	0.70	72.4	50.4	51.9	45.3

Max. DG1 Load @ 0.9 pf	Load on DG2 @ 0.9 pf	Total DG1/DG2	Total Load @ 0.9 pf
kVA	kVA	kVA	%
69.3	64	132.8	83.00
69.3	77	145.9	91.00
69.3	75	144.5	90.30
69.3	64	133.5	83.40
69.3	76.7	146	91.3
69.3	76.7	146	91.3
69.3	60.6	129.9	89.2
69.3	82	151.3 *	94.5
69.3	60.1	129.4	80.2
	62.7	132	82.5

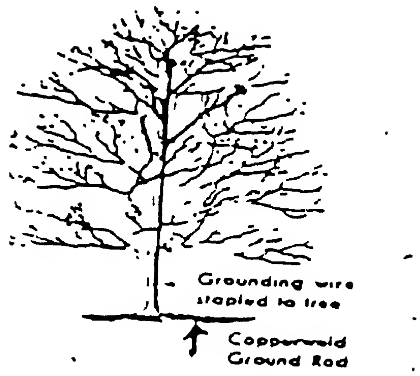
* The peak load at 0.95 lag pf will be 143 kVA(89%)

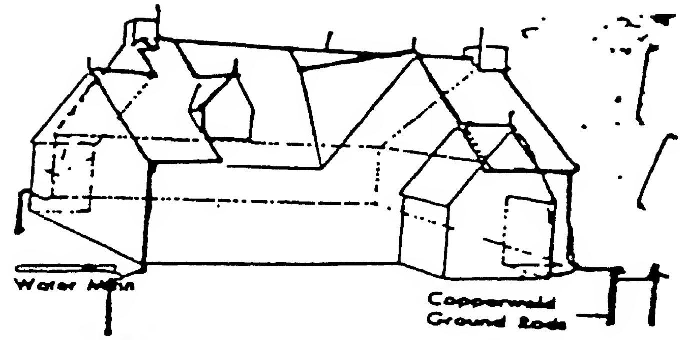
APPENDIX - 3/10

TOTAL TOWNSHIP LOADS

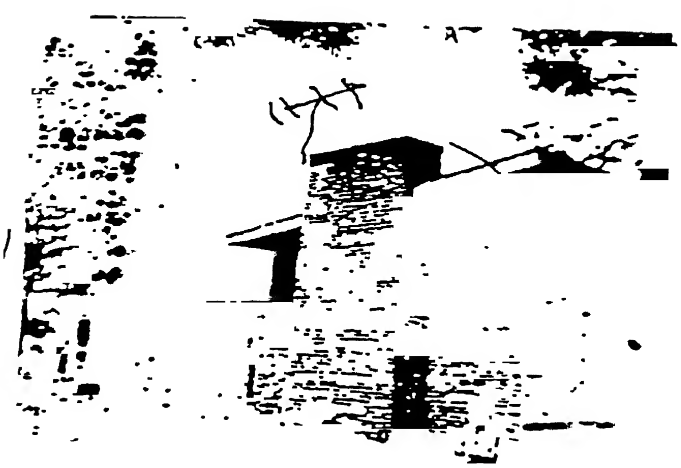
Types of Qtrs.	kW load	# of Geysers	No. of Quarters
'A'	19.43	2	1
'B'	38.67	5	4 (including guest house)
'B2"	60.55	5	5
MC block (modified C)	36.85	10	5
'C'	132.6	5	18
'D'	407.2	15	80
Temporary block	33.12	-	23
Total	728.42	42	136

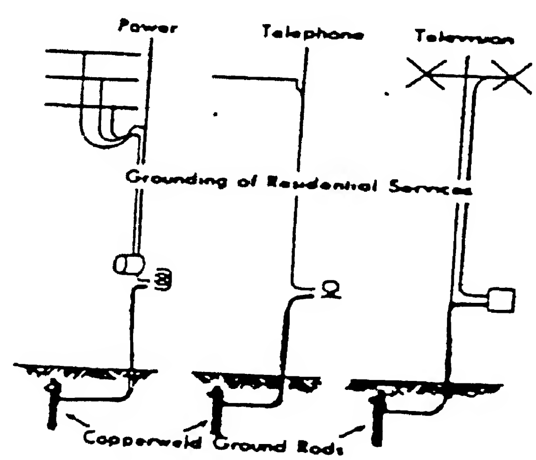
- All geysers are of 1.5 kW
- All quarters have heaters (for kitchen) of 1.5 kW or 2 kW

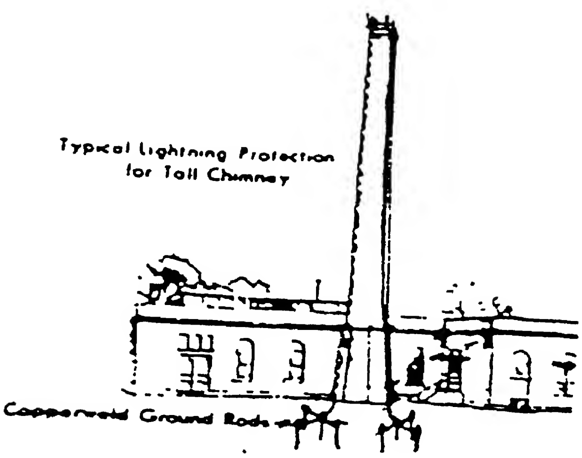


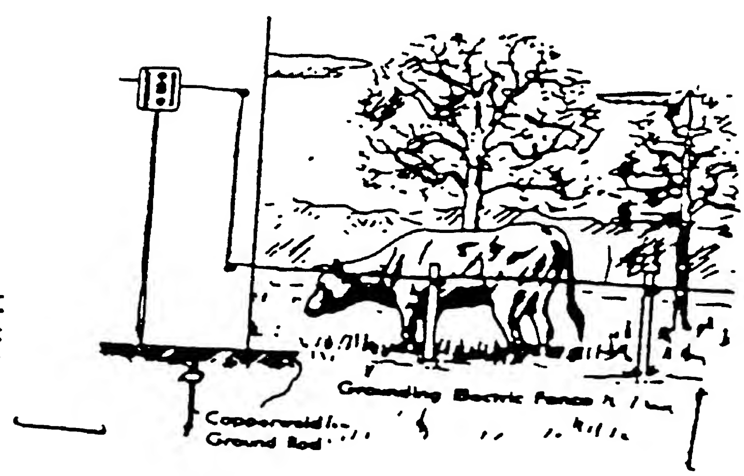


Typical Lightning Protection Planned for Residence









APPENDIX - 4/1

NAME PLATE DETIALS OF ALTERNATORS

	DG-1	DG-2
Make	Crompton Greaves	Kirloskar
kVA	125	160
RPM	1500	1500
Volts-Ph	415 (3ϕ)	415 (3ϕ)
AC Amps	174	222
DC Volts	275	70
DC Amps	8.5 A	2.0 A
PF	0.8	0.8

APPENDIX - 4/2

SPECIFIC ENERGY GENERATION RATIO SEGR FOR THE YEAR 1996
(125 kVA & 160 kVA DG Sets)

Month	Units Generated (kWh)	HSD Consumed (Ltrs)	SEGR kWh/ltr
Jan'96	10166	3705	2.74
Feb	12487	4910	2.54
Mar	26505	10760	2.47
Apr	13681	5365	2.55
May	20448	7950	2.57
Jun	19812	6750	2.93
Jul	33800	11970	2.82
Aug	36313	12920	2.81
Sep	33539	12325	2.72
Oct	21573	8925	2.42
Nov	12191	4390	2.77
Dec	8357	3155	2.65

Average SEGR = 2.66

APPENDIX - 4/3

ENERGY BALANCE OF 125 kVA DG SET

Energy Balance

Trial conducted on	=	3.5.97
Trial duration	=	12.26 p.m to 13.49 p.m
Initial kWh reading	=	0000.06
Final kWh reading	=	0064.02
Units generated	=	63.96 kWh
Average Running load	=	50.4 kW
% Loading	=	$\frac{50.4}{100}$ = 50.4
HSD Fuel consumption during trial period (computed from dip stick readings)	=	28.64 ltrs
A. Heat Input	=	23.5 X 10,800
	=	2,53,800 kcal/h
B Heat Output		
Electricity Generation	=	63.96 X 860
	=	55,006 kcal/h
	=	21.7% of heat input

Heat given off through Radiator

Ambient air temperature	=	30°C
Temperature of exit air	=	48°C
Temeprature rise in air stream	=	18°C
Average velociaty of air	=	9.2 m/sec
Average cross-sectional area of radiator	=	0.78 m^2
Mass flow rate of air	=	0.78 X 9.2 X 1.2
	=	8.6 kg/sec
	=	30,960 kg/h
Heat carried by air	=	30,960 X 0.24 X 18
	=	1,33,747 kcal/h
	=	52.7% of heat input

Appendix - 4/3 contd.

Heat loss due to flue gas

% of CO_2 in flue gas	=	7.25
% excess air	=	$\left(\frac{13.6}{7.25} - 1\right) \times 100$
	=	87.6%
Theritical air required for fuel oil	=	14 kg/kg of fuel
Total air supplied	=	14 X (0.876 + 1)
	=	26.26 kg/kg of HSD
Total flue gas quantity	=	26.26 X 28.64
	=	617 kgs.
Flue gas temeprature	=	375°C
Heat taken by flue gas	=	617 X 0.24 X (375-30)
	=	51088 kcal
	=	20% of heat input

Heat Balance

Item	kcal/h	%
Heat Input by fuel	253800	100
Heat output		
a Thermal Efficiency/ Electricity Generation	55006	21.7
b Heat given off by Radiator	1,33,747	52.7
c Heat loss to flue gas	51,088	20.1
d Surface Loss + unaccounted losses	13,959	5.5

APPENDIX - 4/4

ENERGY BALANCE OF 160 kVA DG SET

Energy Balance

Trial conducted on	=	3.5.97
Trial duration	=	11.23 p.m to 12.01 p.m
Initial kWh reading	=	0000.02
Final kWh reading	=	0034.37
Units generated	=	34.35 kWh
Average Running load	=	62.8 kW
% Loading	=	$\frac{62.8}{128}$ = 46.2
HSD Fuel consumption during trial period (computed from dip stick readings)	=	13.93 ltrs
A. Heat Input	=	11.43 X 10,800
	=	1,23,120 kcal
B Heat Output		
Electricity Generation	=	34.35 X 860
	=	29,541 kcal
	=	24% of heat input

Heat given off through Radiator

Ambient air temperature	=	30°C
Temperature of exit air	=	40°C
Temprature rise in air stream	=	18°C
Average cross-sectional area of radiator	=	1.15 m^2
Average velocity of air	=	3.8 m/sec
Mass flow rate of air	=	1.15 X 3.8 X 1.2
	=	5.24 kg/sec
	=	18,864 kg/h
Heat carried by air	=	18,864 X 0.24 X 18
	=	45,274 kcal/h
	=	37% of heat input

Appendix - 4/4 contd.

Heat loss due to flue gas

% of CO_2 in flue gas	=	6
% excess air	=	$(\frac{13.6}{6} - 1) \times 100$
	=	127%
Thoeritical air required for fuel oil	=	14 kg/kg of HSD
Total air supplied	=	14 X (1.27 + 1)
	=	31.78 kg/kg of HSD
Total flue gas quantity	=	31.78 X 13.6
	=	442.7 kgs
Flue gas temeprature	=	358°C
Heat taken by flue gas	=	442.7 X 0.24 X (358-30)
	=	34,849 kcal
	=	23.2% of heat input

Heat Balance

Item	kcal/h	%
Heat Input by fuel	123120	100
Heat output		
a Thermal Efficiency/ Electricity Generation	29,541	24
b Heat given off by Radiator	45274	37
c Heat loss to flue gas	28520	23.2
d Surface Loss + unaccounted losses	19785	15.8

APPENDIX - 4/5

MONTHLY RECORD OF DG SET # HOURS OF OPERATION OF DG SET

Month/ Year	DG Set -1 125kVA	DG Set -2 160 kVA	Hired DG Set 180 kVA	Total hrs.	Power Failure # of timer
Jan'96	79	88		167	60
Feb	125	115		115	44
Mar	249	249		249	40
Apr	153	115		115	62
May	208	210		210	80
Jun	164	179		179	110
Jul	295	278		278	93
Aug	312	305		320	78
Sep	258	319		319	47
Oct	108	248	255(62)	250	95
Nov	62	151	203(60)	-	-
Dec	-	124	250(13)	124	85
Total	**2013**	**2381**	**705**	**2326**	**794**
Jan'97	118	224	163 (87)	324	91
Feb	114	262	57 (200)	262	90
Mar	181	211	177 (22)	392	92
Apr	326	289	150 (100)	442	82

Note:- **Figures in bracket indicates breakdown and non-availability of hired of 180 kVA DG set.**

APPENDIX - 4/6

SPECIFICATIONS OF COOLING TOWERS
SALIENT FEATURES

Outline of Construciton

Shaped like a cylinder, with an axial flow fan mounted on top to give vertical discharge. Ideal for cooling efficiecny and space economy.

Casing (F.R.P)

Has structural strength to withstand high wind velocities and vibrations. Resistant to local impacts. In case of damages, local repairs can be done easily.

Water Basin (F.R.P)

Made of F.R.P., it is bowl shaped with a cylindrical auxiliary suction tank at the bottom. The drain provided facilitates easy removal of accumulated dirt from the bottom of the tank.

Tower Supporting Structure

The supporting framework for the tower casing and the water basin is made of galvanised steel and protected with epoxy painting.

Fillings

The fillings are made of Polyvinyl Chloride. They have excellent heat exchange efficiency and remarkanly good resistance to corrosion.

Appendix - 4/6 contd.

Sprinkler

Consists of 4 P.V.C pipes screwed into a rotating head. It is mounted on top of the P.V.C. stand pipe located centrally in the tower. The holes along the sprinkler pipes discharge circulating water at low pressure, and its reaction force rotates the sprinkler assembly at 5 to 7 TPM.

The rotary sprinkler head is specially designed with respect to corrosion, abrasion and assembling. The sprinkler head is made of aluminium alloy and fitted with sealed ball bearings to take care of thrust and radial loads.

Fan

Axial flow type. Made of special aluminium alloy, it has 4 blades with adjustable pitches. Specailly designed for cooling towers, these fans deliver large air volumes at high efficencies and low noise levels.

Technical Data for Cooling Towers

Sl.No	Items	100 TR	120 TR	300 TR
1	Fan			
	No. of blades	4	6	4
	Fan Daimeter (mm)	1500	1500	2400
	Fan Speed (RPM)	720	720	400
	Air Flow Rate (m^3/min)	750	900	2200
2	Fan Motor			
	HP	5	7.5	10
	Syn Speed (RPM)	750	750	1500
3	Casing & Water Basin			
	Material		FRP	
4	Fillings			

Appendix - 4/6 contd.

Sl.No	Items	100 TR	120 TR	300 TR
	Material		PVC	
	No. of layers	2	2	2
	Total no. of fillings	126	126	364
5	Overall Dimennsions			
	Diameter (mm)	2900	2900	4800
	Height(mm)	3518	3518	4500
	Foundation PLD(mm)	2800	2800	4700
6	Weight			
	Shipping (kg)	700	740	2160
	Operation (kg)	1300	1375	4160
7	Piping Connection			
	Water inlet (mm)	125	125	200
	Water outlet (mm)	125	125	200
	Overflow (mm)	50	50	100
	Drain (mm)	50	50	50
	Float Valve (mm)	20	20	32
	Quick Filler (mm)	20	20	32

APPENDIX - 4/7

MEASURES FOR LUBRICATION OIL CONSERVATION FOR DIESEL GENERATOR SETS

1. Improve air filtration

2. Reduce fuel dilution by :

   a. ensuring proper atomisation
   b. having correct engine temperature
   c. having proper air-fuel ratio
   d. ensuring proper crankcase venting
   e. eliminating worn out rings and cylinder liners.

3. Check insolubles build-up in oil by using proper air, oil and fuel filters.

4. Reduce oil loss by proper clearance between valve stem and guide.

5. Reduce oil loss from piston by :

   a. reducing carbon deposits on top land
   b. avoiding bore polishing and glazing
   c. attending to ring wear.

6. Provide by-pass purification system or remove insolubles by centrifuging.

7. Use long drain oils with improved air and oil filters.

8. Monitor TBN values more closely where high sulphur diesel is used.

9. Switch on to multigrade oils for oil as well as fuel economy.

10. Check for leaks in the lubrication system and attend to them promptly.

11. Change oil on condition basis and not on the thumb rule recommended by oil companies or engine builders. Field oil testing system are readily available in the country.

12. Oil never deteriorates. It goes off specs temporarily. The drained oil can be re-refined and brought to proper level by appropriate re-refining and reclamation techniques. For further details on refining, consult PCRA* booklet titled *"How to Conserve Lubes"* (through recycling). For any further information on this, please contact PCRA, New Delhi.

---

* PCRA - Petroleum Conservation Research Association.

* Note : Oil refers to engine lubricant and fuel refers to diesel oil.

APPENDIX 4/8

GENERAL OPERATING TIPS FOR FUEL EFFICIENCY FOR DIESEL GENERATOR SETS

1. Select proper fuel. If injection system can tolerate more viscous fuels like LDO, furnace oil or other residual fuels like LSHS or HPS, go for higher viscosity fuels.

2. Ensure proper storage and handling of fuel. Dirt and contamination will make the fuel go off specification.

3. Load the DG sets above 50 percent for large D G sets, and above 60 percent for small sets.

4. Ensure proper fuel injection, correct viscosity and temperature, timing proper mechanical condition of components, and prevent fuel contamination.

5. Select proper lubricant, monitor lubricant condition through regular sampling and analysis of used oil. Ensure proper lubricant cooling and consumption. (Thicker oil cause 2 per cent excess fuel consumption).

6. Externally clean the air filters regularly, to ensure proper filtration and cleanliness of intake air.

7. Avoid leakages of fuel oil and lube oil, even though they may be of minor nature. They are a major cause for higher fuel and lube consumption.

8. Normally, engine oils of SAE 40 grades are used in DG sets, unless otherwise recommended by the manufacturers. Use of multigrade and higher performance level oils with high detergency, alkalinity reserve and antiwear properties help in both lube and fuel conservation in addition to improving engine mechanical efficiency.

Appendix - 4/8 contd..

9. Check compression pressure regularly if provision exists. Attend to stuck piston rings, leaky valves, clogged ports, excessive liner and ring wear, etc, promptly.

10. Insulate exhaust piping to reduce air temperature inside the generator room as the higher intake air temperature increases the specific fuel consumption and reduces engine output (engine output reduces by about 5 percent for 10° C rise in intake temperature).

11. Avoid exhaust gas temperature above 450° C. High exhaust temperatures due to overload and restricted air supply, could lead to lower fuel efficiency as well as fouling of turbo-chargers.

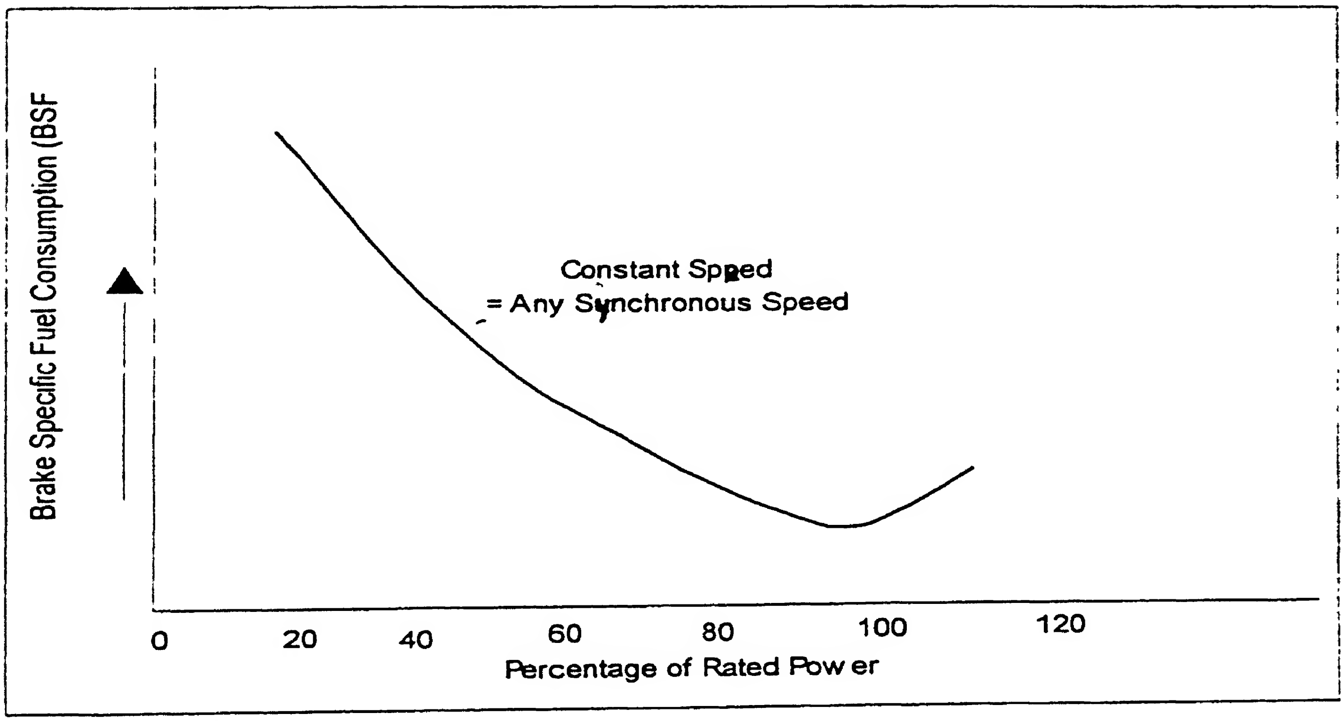
12. Avoid over lubrication to prevent deposits inside the engine and on the turbo-charger blades.

13. Maintain the cooling circuit system and clean heat exchangers regularly. Meet manufacturer's norms on cooling water temperature, back pressure, flow rate, quality etc.,

14. Adopt preventive or preferably predictive maintenance programmes.

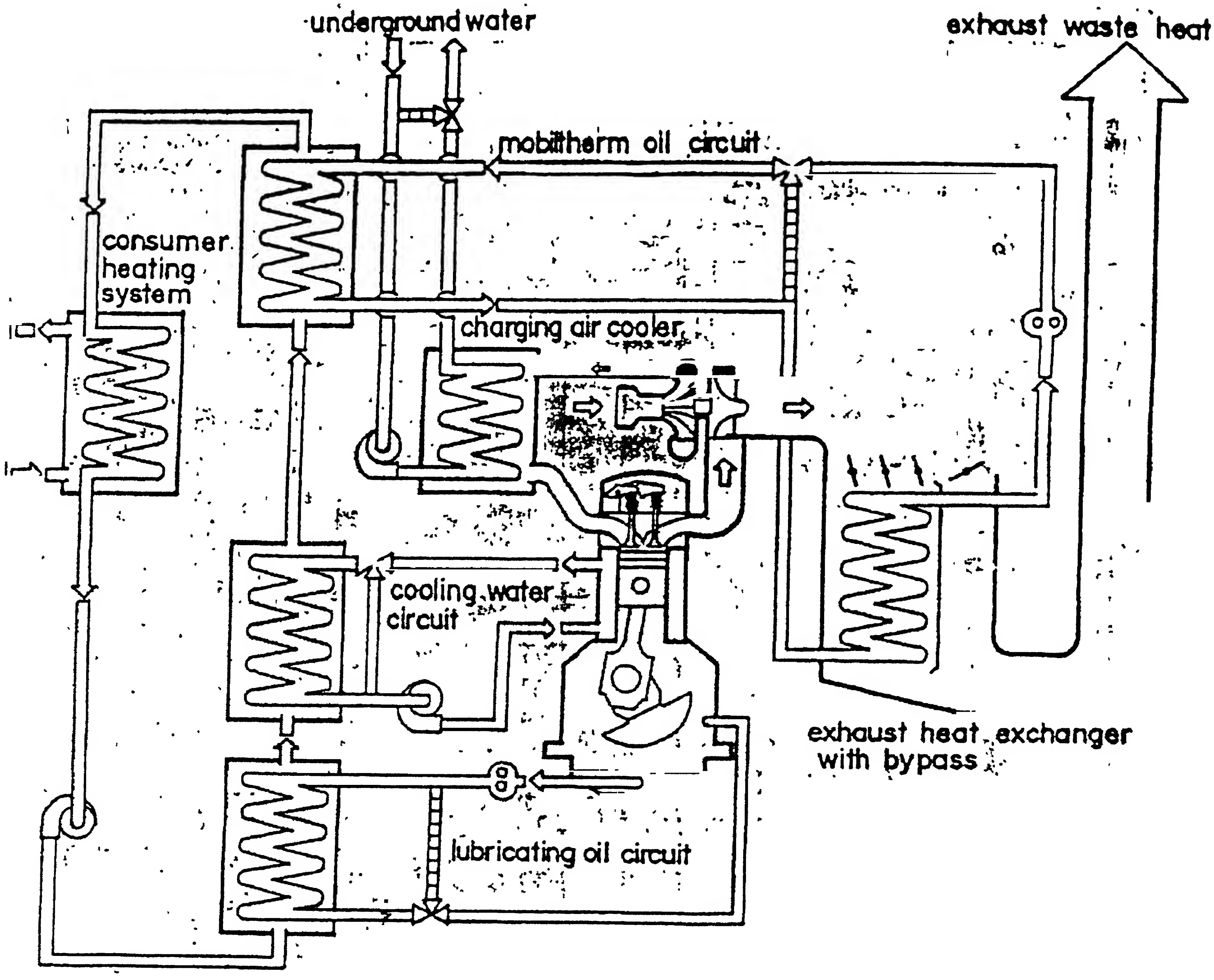
15. Attempt waste heat recovery, if technically and economically viable.

APPENDIX - 4/9



Characteristic curve bsfc VS. LOAD AT A constant governed speed

APPENDIX - 4/10



Waste Heat Recovery, Generation of Hot Water For Heating Purpose

APPENDIX - 5/1

L.T. MOTOR LOADING PARAMETERS

SL. No.	APPLICATION / CONNECTED EQPT.	RATED HP	Measured 3 Phase Parameters					LOADING	REMARKS
			Volts	Amps	P.F.				
			V	A	Cos ϕ	kVA	kW		
	KAOLIN PLANT								
1	Kaolin Plant Main	-	432	45.3	0.72	34.5	24.0		
2	Supply Fan	15 0	433	8.8	0.77	7.2	5.7	50.9	Outlet damper 50% closed
3	Exhaust Fan	30.0	433	32.3	0.82	17.5	14.4	64.3	$\lambda - \Delta$
4	Chamber Agitator	15.0	433	6.8	0.68	8.4	5.4	48.3	$\lambda - \Delta$
5	Screw Feeder	3.0	433	1.5	0.40	1.5	0.6	26.8	
6	Tank Agitator	5.0	433	4.0	0.35	4.8	1.1	29.5	Ist = 7.6 A
7	Press Filter Pump	10.0	433	7.5	0.40	1.8	2.1	28.2	
8	Air Compressor	2.0	431	2.7	0.60	17.4	1.2	80.4	
9	SP 3 Sample Pump	15.0	431	14.6	0.88	10.2	10.8	96.5	
10	Transfer Pump	15.0	431	13.3	1.84	1.5	7.2	64.3	Ist = 18 A
11	Kaolin Conveyor	3.0	380	3.0	0.47	1.5	1.0	44.7	Ist = 15 A
	TOTAL	**118**	-	**88.0**		**71.8**	**49.6**		
	WATER PUMPING SYSTEMS								
1	Submersible Pump Motor	20.0	388	32.4	0.86	21.6	18.6	124.7	V drop in cable 12 Volts
2	Bagru Borewell	2.5	388	5.4	0.95	2.0	1.6	85.8	
3	Pump House - Borwell	2.5	-	3.4	0.95	2.1	1.8	96.5	
4	Water Pump O/H Tank	2.5	386	2.0	0.80	1.7	1.5	80.4	
	TOTAL	**27.5**	-	**43.2**		**27.4**	**23.5**		
	PULVERISER SECTION								
1	Main Incomer - PV1	-	422	55.0	0.80	36.0	30.0	-	
2	Hammer Mill - PV1	60.0	395	45 /53	0.83	40.0	29.0	64.8	Slip ring motor
3	Conveyor - PV1	5.0	395	3.1	Low	2.1	1.5	40.2	
4	BSEB Incomer to PV plant	-	395	100.0	0.99	68.1	66.9	-	60 kVAr cap.
5	Roller Mill - PV2	30.0	396	34.0	0.9/0.8	20.0	18.0	80.4	High effi. motor installed
6	Roller Mill Fan - PV2	30.0	396	28.7	0.77	19.5	15.3	68.4	High effi. motor installed
7	Bag Conveyor	2.0	410	20.0	Low	1.2	0.6	40.2	
	TOTAL	**127.0**		**138.0**		**82.8**	**64.4**		

Appendix - 5/1 contd..

SL. No.	APPLICATION / CONNECTED EQPT.	RATED HP	Measured 3 Phase Parameters Volts V	Amps A	P.F. Cos φ	kVA	kW	% LOADING	REMARKS
	BAUXITE SCREENING PLANT								
	CRUSHER - 1								
1	Main Incomer - Crusher	-	415	32.0	0.50	23.0	11.2		
2	Belt Conveyor - Trial 1	10.0	424	12.2	0.50	8.7	4.2	56.3	
3	" - Trial 2	10.0	424	4 5	Low	4.5	1.5	20.1	Idle
4	" - Trial 3	10.0	424	7 6	0.85	6.7	5.7	76.4	On load = Ist = 314
5	Screen Conveyor	5.0	424	8.0	0.30	6.3	1.2	32.2	
6	BSP Conveyor - 1	10.0	417	6.6	0.50	4.6	2.1	28.2	
7	BSP Conveyor - 2	20.0	417	5.0	0.44	4.3	2.5	16.8	Ist - 30A
	TOTAL	**45.0**	-	**36.6**		**26.5**	**11.7**		
	CRUSHER - 2								
8	Belt Conveyor - Trial 1	20.0	370	14.7/14	0.76	14.0	7.2	48.3	DG Supply
9	Trial 2	20.0	450	17.2	0.57	13.0	7.5	50.3	BSEB supply
10	Feeder Chain	15.0	450	13.8	0.64	9.9	7.8	69.7	Single V belt against 3 belts
11	Screen Motor	5.0	370	3.8	Low	2.1	1.2	32.2	
	TOTAL	**40.0**		**48.8**		**26.0**	**16.5**		
	ROPEWAY								
12	Main Drive	20.0	370	8.9/14	0.65/0.89	8.7/12.3	7.2	48.3	Slip ring motor
13	Air Compressor	5.0	370	6.8	0.85	3.9	3.6	96.5	
	TOTAL	**25**		**21.0**		**15.9**	**10.8**		

APPENDIX - 5/2

LOADING PARAMETERS OF MOTOR COUPLED TO PULVERISER PLANT

V	I	pf	kW	kVA	kVAr	Hz	Remarks
Pulveriser Fan - 30 HP							
417	32.3	0.81	19.0	23.5	13.8	50.8	
399	31	0.81	17.3	21.4	12.6	48.3	
434	32.8	0.81	20.0	24.7	14.4	51.4	
413	32.3	0.81	18.8	23.1	13.5	49.7	
434	33.6	0.82	20.5	25.2	14.6	51.9	
Vertical Roller Mill - 30 HP							
437	28.5 IST = 48/121	0.74	15.9	21.5	14.5	52.1	λ - Δ c/o = 3sec. V drop = 8V
434	26.8 IST = 53/88	0.73	14.7	20.2	13.9	52.1	λ - Δ c/o = 6sec N/L V drop = NIL
135	34.2 IST=67/80	0.79	20.4	25.7	15.7	51.8	λ - Δ c/o = 9 secs. V drop = 1V on load;
Pulveriser - I 60 hp Motor - Load readings							
433	57.9	0.85	37.1	43.5	22.7	51.9	Tripped due to O/L
431	66.3	0.86	42.4	49.4	25.4	51.7	
434	31.1	0.59	13.7	23.3	18.9	52.7	
401	50.8	0.84	29.5	35.3	19.3	48.7	3 Mt / bag
414	63.1	0.88	39.6	45.2	21.8	50.1	2½ Mt/bag
422	58.9	0.83	35.8	43.1	23.9	51.1	3½ Mt/bag
415	68.2	0.88	43.2	49.0	23.1	50.0	-
PV plant I/C BSEB Load Readings							
416	102	1.0	73	73.1	4.2	51.4	With 60 kVAr
399	90.8	0.99	62.3	62.7	6.78	48.5	
415	105	1.0	75.1	75.1	2.21	49.5	
413	122	0.82	71.4	86.8	49.4	49.4	W/o capacitor

INSTALLATION OF SOFT STARTERS FOR MOTORS

Sl. No.	APPLICATION / CONNECTED EQUIPMENT	RATED kW	VOLT -AGE	Pf	REDUCT IN VOLT %	EDUCTIO IN LOSSE %	ANNUAL AVINGS IN kWh	ANNUAL ENERGY SAVINGS IN Rs (X)	REDUC TION IN kVA LOAD	ANNUAL DEMAN AVINGS IN Rs (Y)	IMPLEME NTATION COST IN Rs	NET ANNUAL COST SAVING IN Rs (X + Y)	SIMPLE PAYBACK PERIOD IN YEARS
1	Submersible Pump Motor	15.0	388	0.75	4	7.26	1070	3531	3	4500	32000	8031	4 0
2	Belt Conveyor	7.5	424	0 5	10	19 60	869	2868	2	3000	21500	5868	3.7
3	Screen Conveyor	3 7	424	0.3	17	31.24	396	1306	1	1500	21500	2806	7 7
4	BSP Conveyor - 1	7 5	417	0.5	10	19 60	435	1434	2	3000	21500	4434	4 8
5	BSP Conveyor -2	15 0	417	0 44	12	22 97	655	2161	3	4500	21500	6661	3 2
6	Belt Conveyor	15 0	450	0 57	8	15 83	1204	3973	3	4500	33000	8473	3 9
7	Feeder Chain	11 0	450	0 64	6	12 29	1012	3340	3	4500	28000	7840	3 6
8	Screen Motor	3.7	370	0 46	12	21 83	277	913	1	1500	21500	2413	8 9
						TOTAL=	5917	19527	18	27000	200500	46527	4.3

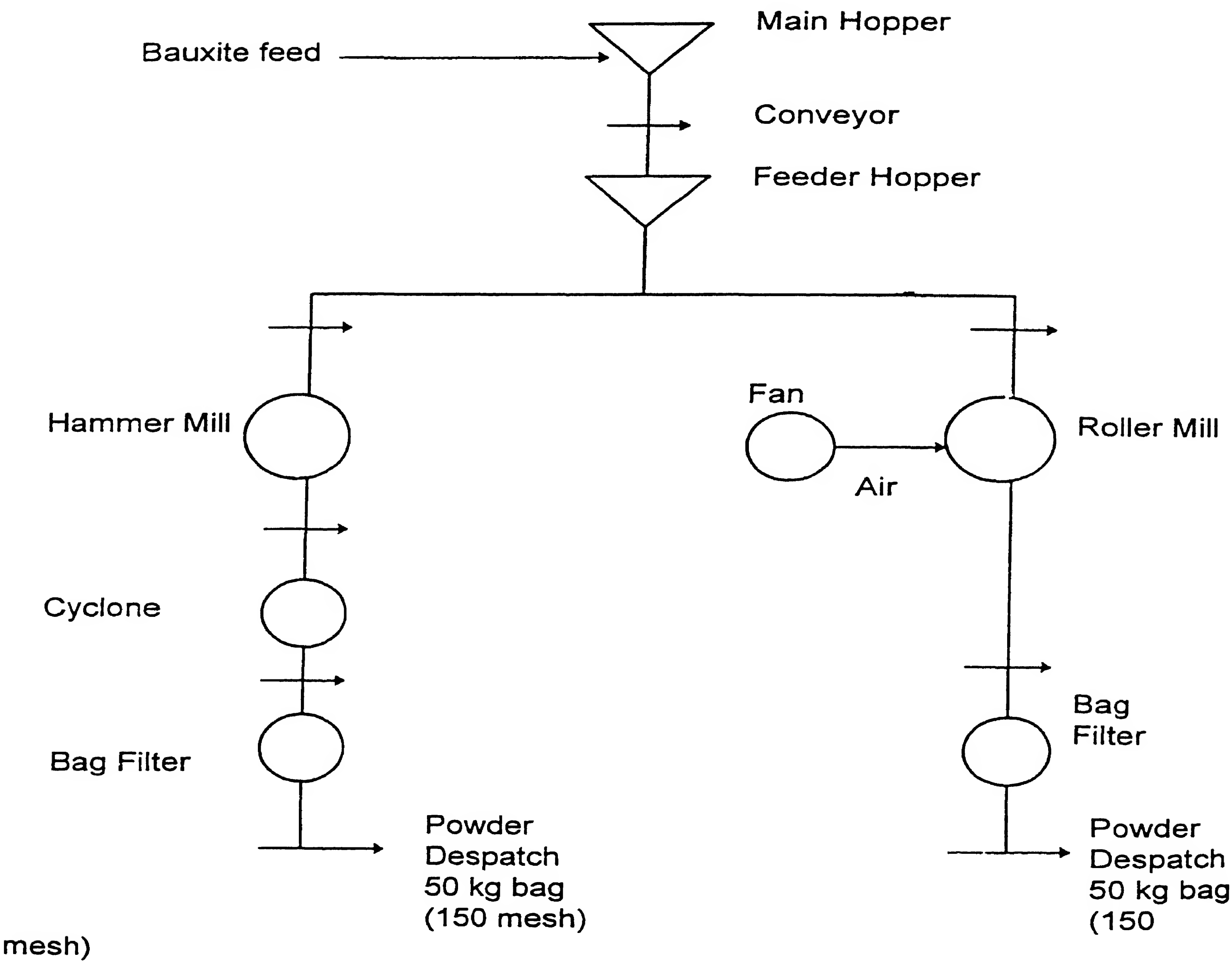
APPENDIX - 5/4

OPTIMUM SIZING AND USE OF ENERGY EFFICIENT MOTORS

SL No	APPLICATION/ CONNECTED EQUIPMENT	PRESENT DRIVE kW	MEASURED kW	F/L EFFI. η	F/L POWER kW	OPERT LOSSES OLD	PROPOSED HIGH η MOTOR KW	OPERT. EFFIC WITH NEW DRIVE	F/L POWER	DEMAND FACTOR NEW	OPERT EFF NEW	OPERT. LOSSES NEW	REDUC. IN LOSSES	ANNUAL OPERT HOURS	ANNUAL SAVINGS kWh	COST SAVINGS Rs	INSTALL-ATIONCOST Rs	PAYBACK PERIOD YEARS
1	Supply Fan	11.0	5 70	0.82	13 41	1.19	7 5	0.88	8.52	0 67	88 21%	0 67	0 52	4800	2475	8167	12000	1 47
2	Exhaust Fan	22 5	14 40	0 82	27 44	2 72	18 5	0 92	20 11	0 72	92 20%	1.12	1 60	4800	7668	25303	33000	1.30
3	Belt ConveyorBSP	7.5	5.70	0 82	9.15	1.02	7 5	0.88	8 52	0 67	88 21%	0 67	0 35	4800	1679	5540	12000	2.17
4	Screen Conveyor	3.7	1.20	0 82	4 51	0 34	3 7	0.84	4 40	0 27	74 98%	0 30	0 04	4800	211	697	6000	8.61
5	BSP Conveyor - 1	7.5	2 10	0.82	9.15	0.68	5.0	0 84	5 95	0 35	79 27%	0 44	0 24	4800	1171	3865	6000	1.55
6	BSP Conveyor - 2	15.0	2.70	0.84	17 86	1.13	7 5	0 88	8 52	0.32	83.25%	0 45	0.67	4800	3235	10675	12000	1.12
7	Belt Conveyor	15.0	7.50	0.84	17 86	1.40	11 0	0 90	12 22	0.61	90 00%	0 75	0 65	4800	3112	10271	20000	1.95
8	Feeder Chain	11.0	7 80	0.82	13 41	1.42	11 0	0.90	12 22	0 64	90 09%	0.77	0 65	4800	3123	10306	20000	1.94
9	Screen Motor	3.7	1 20	0 82	4.51	0 34	2 2	0 84	7 50	0 16	90 99%	0 11	0 24	4800	1133	3740	5000	1.34
											TOTAL =				23808	78565	126000	1.60

APPENDIX - 5/5

PROCESS FLOW CHART
(PULVERISING PLANT)



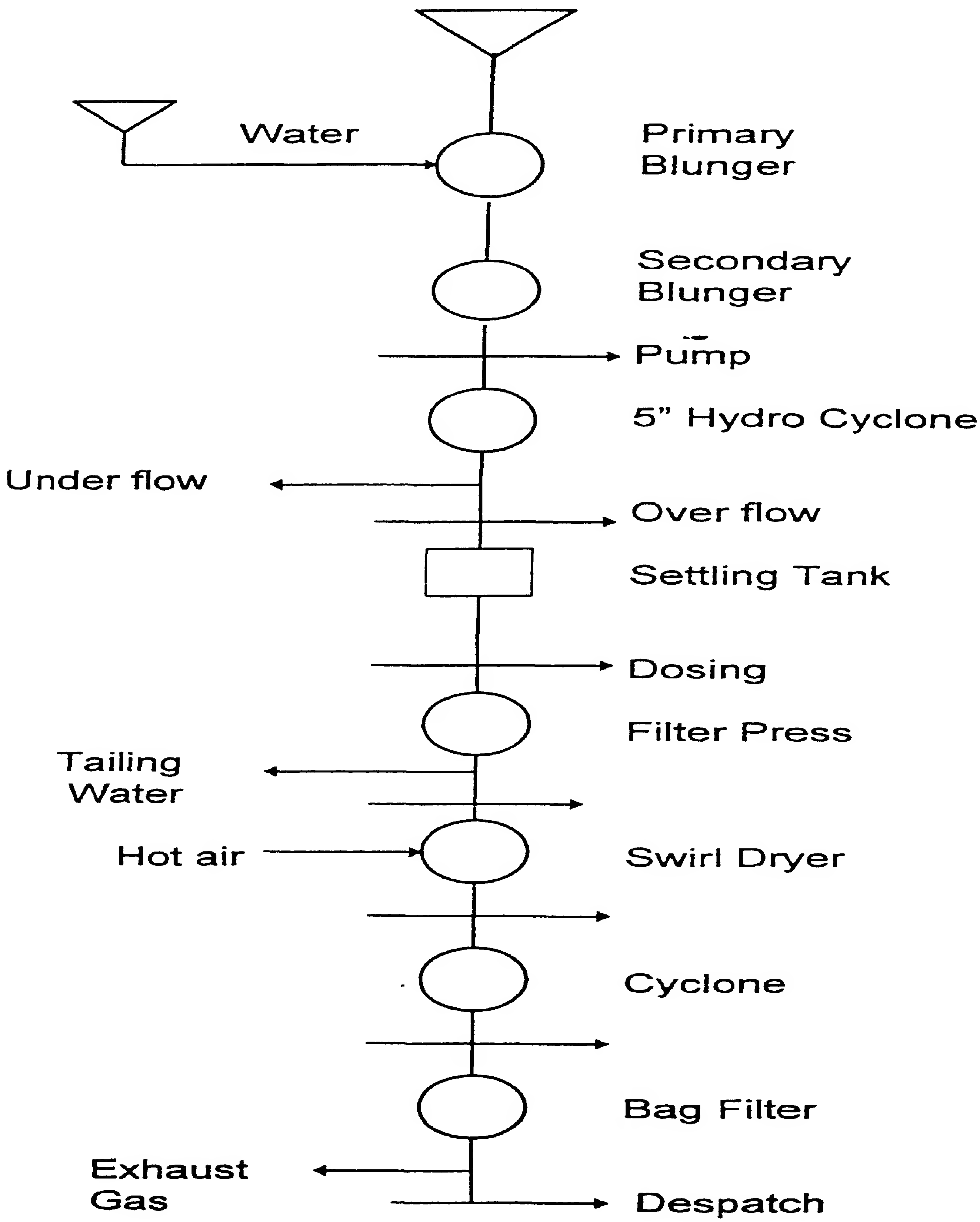
APPENDIX - 6/1

POWER GENERATION BY A.C GENERATORS FIXED TO POWER TAKE-OFF OF CRUSHING AND SCRRENING PLANT CATERPILLAR ENGINES

Total kW	=	25 + 25
	=	50 kW
Actual power demand	=	11.7 + 16.5 = 28.2
(by measurement)	=	28.2 X 14 X 300
	=	1,18,440 kWh/year
Annual value of power	=	1,18,440 X 3.30
	=	Rs. 3,90,852/-

APPENDIX - 7/1

PROCESS FLOW CHART
(KAOLIN PLANT)



APPENDIX - 7/2

SURFACE HEAT LOSSES FROM UNINSULATED SHELL OF HOT AIR GENERATOR

Sl. No.	Location	Temp. °C	Effective area m^2	Heat loss kcal/h
1.	Burner Side - front plate	108	3.14	3127.4
2.	Shell - Front section	170	9.42	14730
3.	Shell - Mid section	65	9.42	3372.4
4.	Shell - End section	114	9.42	9851.4
5.	End plate	72	3.14	1236.5
	TOTAL			**32,317.7**

Total surface heat loss in hot air generator (Kaolin plant) = 32,317 kcal/h

A conservative estimate assumes that about 75% of the heat losses could be successfully saved by improving and installing insulation to exposed surfaces.

Hence, heat savings = 32317 x 0.75

= 24238.3 kcal/h

Equivalent HSD savings = 2.24 kg/h

= 2.73 l/h

= 2.73 x 10 x 300

= 8190 l/y

Value of savings = 8190 x 9

= Rs.73,710/y

Estimated investment for implementation = Nil
(Since all materials available at site given by supplier)

Simple payback period = Immediate

APPENDIX - 7/3

HEAT LOSS IN HOT AIR GENERATOR (KAOLIN PLANT) DUE TO LEAKAGES AT JOINTS ON THE SHELL

Sl. No.	Location	Temp. °C	Effective area m^2	Heat loss kcal/h
1.	Burner mounting cartridge	156	0.06	94
2.	Burner side front plate	144	0.13	203.3
3.	Shell end plate joints	110	0.10	104.5
	TOTAL			**401.8**

Heat loss because of leakages in hot air generator (Kaolin plant) = 401.8 kcal/h

BY plugging the leaks and rectification work, it is assumed that 75% of leakages will be stopped.

Hence, heat savings = 401.8 x 0.75

= 301.4 kcal/h

Equivalent HSD savings = 0.03 kg/h

= 0.04 l/h

= 0.04 x 10 x 300

= 120 l/y

Value of savings = 120 x 9

= Rs.1080 /y

Estimated investment for implementation = Nil
(Since all materials available ready with supplier)

Simple payback period = Immediate

APPENDIX - 7/4

HEAT LOSS DUE TO EXHAUST GAS IN HOT AIR GENERATOR (KAOLIN PLANT) AND WASTE HEAT RECOVERY

A. Heat Loss due to Exhaust Gas

% CO_2 in exhaust gas	= 6
% excess air	$= \left(\frac{13.6}{6} - 1\right) \times 100$
	= 127%
Theoretical air required for fuel oil	= 14 kg/kg of fuel
Total air supplied	= 14 x (1.27 + 1)
	= 31.78 kg/kg of HSD
Total exhaust gas quantity	= 31.78 x 19.6
	= 622.89 kg/h
Exhaust gas temperature	= 204 °C
Heat taken away by exhaust gas	= 622.89 x 0.24 x (204 - 30)
	= 26,012 kcal/h

APPENDIX - 7/5

KAOLIN PLANT HOT AIR GENERATOR

ENERGY BALANCE

Study conducted on 5.5.97.

HEAT INPUT :

Cross sectional area of HSD tank	= 0.598 m^2
Difference in oil level during study	= 0.04 m
HSD consumption per hour (Density = 820 kg/m^3)	= 19.6 kg/h
Total heat input	= 19.6 x 10800
	= 2,11,680 kcal/h

HEAT OUTPUT :

a.	Surface heat loss from uninsulated shell (See Appendix - 7/2)	= 32,317.7 kcal/h
		= 15.3% of heat input
b.	Heat loss due to leakages in shell (See Appendix - 7/3)	= 401.8 heat input
		= 0.19% of heat input
c.	Heat loss in exhaust gas (See Appendix - 7/4)	= 26,012 kcal/h
		= 12.3% of heat input

Appendix - 7/5 contd..

HEAT BALANCE

Particulars	kcal	Percentage
Heat Input		
By fuel	211680	100
Heat Output		
a. Surface heat loss from uninsulated shell	32317.7	15.30
b. Heat loss due to leakages in shell	401.8	0.19
c. Heat loss in exhaust gas	26012	12.30
d. Hot air generation + Unaccounted losses	152948.5	72.21

APPENDIX - 7/6

RECOVERY OF WASTE HEAT IN EXHAUST GAS OF HOT AIR GENERATOR (KAOLIN PLANT)

Thermal energy available in exhaust gas = 26,012 kcal/h

Combustion air requirement = 623 kg/h

Proposed preheated combustion air temperature = 95 °C

Recoverable heat = 623 x 0.21 x (95 - 30)

= 8504 kcal/h

% recoverable heat to total exhaust gas thermal energy $= \frac{8504}{26012} \times 100$

= 32.7%

% recoverable heat to total heat input $= \frac{8504}{211680} \times 100$

= 4%

Savings in HSD fuel oil $= \frac{8504}{10800}$

= 0.79 kg/h

= 0.79 x 10 x 300

= 2370 kg/y

= 2891 l/y

Appendix - 7/6 contd..

Value of savings	= 2891 x 9
	= Rs.26,019 /y
Cost of implementation	= Rs.75,000/-
Simple payback period	= 2.88 years

APPENDIX - 8/1

DETAILS OF FACTORY LIGHTING LOADS

Area	Ceiling fan	Bulb 100 W	MV 125 W	MV 250 W	SV 70 W	Tube Light 40W	Others loads
General office	10	-	-	-	-	15	Exhaust 1 PC-2 A/C-2 xerox - 1
General store	2	-	-	-	-	20	Exhaust - 2
Environment office	2	-	-	-	-	2	-
Elec. Foreman office	1	-	-	-	-	1	-
Geologist office	3	-	-	-	-	4	-
Survey office	1	-	-	-	-	2	Printing M/c - 1
M/c Shop	-	5	-	1	-	1	-
Power house	-	2	-	-	1	3	-
Maintenance garage	4	6	5	1	2	5	Halogen 2
Kaolin plant	-	3	4	-	4	3	Halogen 2
PV Plant	-	3	2	1	2	-	Halogen 4
Loading station Lohardaga	3	3	2	2	2	8	1.6 kW Total
Total kW	1.56	2.4	1.95	1.5	0.98	3.2	8.5
Total	26	24	13	5	11	64	

TATA ENERGY RESEARCH INSTITUTE
BANGALORE

TOWN - SHIP - DETIALS OF LIGHTING & MISCELLANOUS LOADS

Type of orfs	Tube Light		Bulb 40 W		Bulb 100 W		Fan		TV		Fridge		Geyser		Misc
	No.	Total	No.	Total	No.	Total	No.	Total	No.	Total	No.	Total	No	Total	
A.Type	5x1	5	2x1	2	15x1	15	5x1	5	1x1	1	2x1	2	2x 1	2	Exhaust fan-1
B.Type	2x3	6	1x3	3	12x3	36	4x3	12	1x3	3	1x3	3	1x 3	3	-
B-2 Type	2x5	10	1x5	5	7x5	35	3x5	15	1x5	5	1x5	5			-
MC Block	2x5	10	1x5	5	7x5	35	3x5	15	1x3	3	-	-			-
'C' Type	2x18	36	1x18	18	7x18	126	3x18	54	-	-	1x1	1			-
'D' Type	2x80	160	1x80	80	4x80	320	2x180	160	1x3	3	-	-			-
Temp Block	2x23	46	2x23	46	-	-	1x5	5	-	-	-	-			-
Guest House	12x1	12	-	-	3x1	3	1x1	1	2x1	2	2x1	2	2x 1	2	Exhaust fan-1
		285		159		570		265		118		18		13	2

Unloading Station Lohartaga

Halogen lamp	-	500 W x 2	=	1000
Bulb	-	100 W x 10	=	1000
Flood light	-	300 W x 5	=	1500

				3500 Watts

APPENDIX - 8/2

LIGHTING - TYPES OF LUMINAIRES IN TOWN SHIP

Type of fitting		No. Of fittings	Connected Load in kW
40W Tube Light	-	285	14.25
40 W Incandescent	-	-	
60 W Incandescent	-	45	2.70
100W Incandescent	-	660	66.00
125 WMV	-	15	2.25
70 WSV	-	8	0.72
Ceiling Fans	-	265	15.9
Halogen Nos. 500 watts	-	2	1.0
Bulbs 100 watts	-	16	1.6
Flood Light 300 watts	-	5	1.5

Total connected load = 105 kW

Unloading station at Lohardaga = 0.8 kW

Appendix - 8/2 contd.

STREETLIGHTING LOADS

Location /Area	No. of Lights		Fluorescent
	MV - 125 W	SV - 70 W	2 X 40W
Main Road Light	8	12	-
Street Light			
"A" &" B" Type	2	6	2
"MC" & "C" Type	3	-	-
D-1 & D-2	2		2
D-3 & D-4	1	-	2
D-5 & D-6	1	1	2
D-7 & D-8	2	2	2
Temp. Block	3	-	-
In front of M/c. shop	1	-	-
P/House		1	-
Road Light	4	3	2 tube light
Trg. Centre	1	1	2
K.Plant Road	4	-	-
	32X150 = 4.80k W	25 X 90 = 2.20kW	14 X 100 = 1.4 kW

Total connected load = 8:4 kW (Including choke losses)

APPENDIX - 8/3

OBSERVATIONS OF ILLUMINATION LEVELS

Area	Measured Lux	Type of Fittings	Remarks
TRAINING CENTRE			
Conference room	108	6 x 40 W FTL	
Black Board	250	2 x 40 W FTL	
Corridor	55	1 x 100	1 x 40 W FTL to be used
Sample office table	60 - 80	2 x 40 W FTL	-
Computer room	70 - 85	2 x 40 W FTL	-
OFFICE			
Entrance	60	2 x 100 - I	2 x 15 W CFL to be used
Corridor (Wirechain)	40	-	
Admin office	100	4 x 40 W FTL	1 x 40 W To be provided behind Mr.Rajesh Sahey's table
Typing table	180	-	-
Accounts exec.cabin	87	-	-
Computer room	80 - 100	2 x 40 W FTL	-
Record Room	76	OK	-
Lobby at main hall for telephone	54	1 x FTL	-
Fax Room confi.secretary	60	1 x FTL	-
Office entrance gate	Poor	-	1 FTL to be provided
Main gate security	Poor		1 x 70 W Fitting to be provided behind security cabin (Pole available)
Bus Parking area	Low	1 x 70 W SV	Old to be replaced with new fitting
Dispensary entrance	Low	-	Replace Fitting
D8	Low	-	Replace Fitting
D7	Low	-	1 Fitting not OK
D2 LH Corner	Low	125 MV	Replace with 70 W SV
D2 RH Corner	Low	2 x 20 W FTL	- do -
D1-D3	Good	3 x 125 W MV	- do -
PRODUCTION OFFICE			
Corridor	48	1 FTL	OK
Sales Office	105	2 FTL	
Office table	105	1 FTL	
Workshop friends lathe	200	1x200+1x100-I	Provide 6 FTL's
Apollo Long bed lathe	200	2 x 100 - I	As general lighting
Welding area	40	2 x 200	And provide for task lighting
Shaping area	50	-	2 x 24 W CFL
Grinding area	50	-	-

Appendix - 8/3 contd..

Area	Measured Lux	Type of Fittings	Remarks
POWER HOUSE			
DG2 Area	16	1 FTL	1 Additional FTL required
DG1 Area	Low		- do -
Control panel	Low	1 x 200 W Incomer - I	1 x 70 W SV to be
DG Radiator side	48	1 x 200	1 x 70 W SV to be used
Main I/C panel	40	1 FTL	OK
DG Room entrance	10	1 x 70 W	-
WATER STORAGE TANK			
PV Filtration area	60	1 x 100 W - I	1 FTL to be used
Pumping area	Nil	-	1 FTL to be installed
Pathway to Kaolin	Nil	-	Not Working
MAINTENANCE GARAGE			
Working area	20	3 x 125 W MV	36 Fittings are
Welding m/c	14		disconnected but can
Tools area	16		be used elsewhere
Engine Overhauling section	Avg.	1 x 125 W	
Stores	24	1 x 250 W	Replace with 2 x 40 W FTL
Office	50	1 FTL	-
Outside garage	Good	1 x 250 W MV	To be wired separately to put off during day
Dumper parking area & petrol bunk	Good	1 x 250 W MV	
O/D yard carparking area	Poor	-	1 Halogen to be fixed
HT Meter cubicle	Good	1 x 70 W	-
GUEST HOUSE - GUEST ROOM			
Indal House	Good	100 W - I	Lights to be turned off when rooms are not occupied
Outside street light	-	1 x 125 W MV	1 x 70 W SV with new fitting to be replaced
Store room	-	1 x 200 W - I	1 x 40 W FTL to be replaced
Back yard	-	1 x 100 - I	1 x 40 W FTL to be replaced
Heating stove	-	2 kW	This should be replaced by gas stove
`C" type guest house entrance & other C type blocks	Good	1 x 100 W - I	1 FTL between each quarter could from veranda light
Club outside lights	Good	4 x 70 W Sod. Vap.	3 x 70 W fittings may be turned off after 11.00 [illegible]

Appendix - 8/3 contd.

Area	Measured Lux	Type of Fittings	Remarks
PULVERISING AREA			
PV Conveyor	60	1 x 200 + 2 x 100	5 Nos. 1 x 36/40 W on work
Conveyor bin	-	1 x 100 - I	and 5 Nos. of 2 x 36/40 W
PV1 loading area	26	1 x 200 W - I	Fluorescent tube fittings on roof
Stiching	194	-	frame should be provided by
Bag loading area	80	1 x 500 W - H	replacing existing lighting
PV2 loading hopper area	60	1 x 500 W - H	
Outside PV1/PV2	OK	1 x 250 W MV	-
DG Store	OK	1 x 200 W- I	1 FTL to be provided by contractor
DG Room	OK	1 x 200 W - I	-
Storage yard outside	OK	1 x 125 W - I	1 x 125 W required additional
Area between crusher and pulveriser	Dark	-	One to be focused from transformer from opposite 2 x 250 W halogen
BSP conveyor - 2 loading area	Avg.	1 x 125 W MV	New 1 x 70 W sod. Vap. required
VIB screen	Poor	No fitting	1 x 70 W required
CRUSHER - 1			
Machine area	60	1 x 300 W	250 W halogen to be replaced
Conveyor No.1	-	-	1 x 70 W ML lamp required
Ladder stair case between crusher 1 and 2	Poor	-	SV x 1 x 70 W required
CRUSHER - 2			
Conveyor	Avg.	2 x 150 W - I	2 x 70 W ML
Bunker top	Poor	2 x 125 MV	2 x 70 W SV lamp
Crusher - 2 Machine area	30	1 x 500 W H	-
LT shed for crusher	Poor	1 x 70 W MV (Not OK)	1 x 250 W halogen required
Feeding hopper	-	1 x 300 - I	At RH side sitting shed mount 2 x 250 W halogen focused opposite on one new pole
ROPE WAY			
Rest room	60	1 x 40 W	-
Bucket loading area	20	FTL's	2 FTL's at bucket
Ropeway drive area	20	1 x FTL	Loading area to be provided on wall
Outside control room	Good	2 x 70 W SV	OK
Ropeway delivery side	Avg.	1 x 125 MV	
Ropeway structure - 1	Low	As above	1 x 250 W halogen to be focused
Ropeway structure - 2	Low	1 x 300 W	1 x 250 W halogen to be focused

Appendix - 8/3 contd..

Area	Measured Lux	Type of Fittings	Remarks
ROPEWAY			
Main road divider of crusher & BSP PV1 plant	Poor	Nil	2 x 70 W focused to road
Road to crusher 1 and 2	Poor	Nil	1 x 500 W halogen focused to road from crusher - 1 loading area
Length of road deviating from main road to crusher and PV plant (300 mts)	No lights at all	Nil	On 6 poles 1 x 70 W sod. Vap. to be installed with cables etc.
Road to ropeway from junction	Poor	2 x 70 W SV	Additional 2 x 70 W Sodium vapour required
Intersection of main road and PV / crusher near cauvery tank	Good	1 x 70 W	Provided by plant management
Dumper reverse road from crusher	Poor	Nil	3 x 70 W sod. Vap. required
Weigh bridge area	No outside lights		1 x 70 W to focus from the existing pole behind weigh bridge

I = Incandescent Lamp

APPENDIX

TOWNSHIP LIGHTING LOAD DATA

Application Date : 03.05.97 19.30hrs **Date : 04.05.97 7.30 hrs**

Phase	V	A	Cos f	kVA	kW	Amps	PF	kVA	kW	
R	246	21.20	0.85	5.13	4.70	-	-	-	-	
Y	239	21.00	0.86	4.90	4.40	-	-	-	-	
B	232	44.00	0.91	9.31	8.51	-	-	-	-	
	Total before Regulator			**19.34**	**17.61**					
R	249	52.30	0.93	12.90	11.20	45	0.96	11.4	12	IN = 18.1
Y	244	92.60	0.95	22.50	21.50	43	0.95	12.1	11 6	
B	247	88.90	0.96	21.90	21.30	57	0.98	14.9	14.7	
	Total after Regulator			**57.30**	**54.00**			**38.4**	**38.3**	
FEEDERS										
R-1	252	20.80	0.92-0.9	5.16	4.80	14	-	-	3.4	
R-2	252	9.70	0.92-0.9	2.26	2.10	3.2	-	-	0.8	
R-3	252	14.40	0.92-0.9	3.76	3.50	17.3	-	-	4.3	
R-4	252	4.60	0.92-0.9	0.75	0.70	4.5	-	-	0.7	
R-5	252	2.20	0.92-0.9	0.75	0.70	2	-	-	0.5	
	Total	**51.70**		**12.69**	**11.80**	**41**	-	-	9.7	
Y-1	252	31.50	0.92-0.9	8.28	7.70	11	-	-	2.6	
Y-2	252	7.70	0.92-0.9	1.94	1.8	3.7	-	-	0.9	
Y-3	252	18.50	0.92-0.9	4.41	4.10	10.6	-	-	2.6	
Y-4	252	4.60	0.92-0.9	1.03	0.96	3	-	-	0.6	
Y-5	252	7.60	0.92-0.9	1.83	1.70	3.9	-	-	1	
Y-6	252	18.50	0.92-0.9	4.84	4.50	10.8	-	-	2.7	
	Total	**88.40**		**22.32**	**20.76**	**43**	-	-	10.4	
B-1	252	8.90	0.92-0.9	1.61	1.50	1	-	-	**0.2**	
B-2	252	29.00	0.92-0.9	7.63	7.10	13.3	-	-	3.4	
B-3	252	16.50	0.92-0.9	9.57	8.90	15.2	-	-	3.7	
B-4	252	5.30	0.92-0.9	1.40	1.30	18.6	-	-	4.6	
B-5	252	0.00	0.92-0.9	0.00	0.00	0	-	-	0	
B-6	252	23.80	0.92-0.9	6.13	5.70	13.4	-	-	3.2	
	Total	**83.50**		**26.34**	**24.50**	**43**			**15.1**	
	All Total			**61.35**	**57.06**					

APPENDIX - 8/5

REPLACEMENT OF INCANDESCENT LAMPS BY FLUORESCENT LAMP

Sl No	Area	Existing Inc.lamps Watts	# of F.T.L.s to be installed x Watts	Savings Watts #	Annual Energy Saving kWh*	Cost of Implemen-tation Rs.	Annual Cost Savings Rs.
1.	Production office workshop lathe @	1 x 200 1 x 100 2 x 200	6 x 40	400	2112	2400	6970
2.	Water storage tank @	1 x 100	1 x 40	50	264	400	870
3.	Guest house *	1x 100 1x 200 1 x 100	1 x 40 1 x 40 1 x 40	250	1980	1600	6530
4.	Pulverising area *	1 x 200 1 x 200	2 x 40 2 x 40	200	1584	1200	5230
5.	Training centre @	1 x 200	1 x 40	50	264	400	870
	TOTAL				**6204**	**6000**	**20,470**

Choke losses taken into account

Overall payback period = 3 months (@ Rs.3.3/kWh)

* 24 /16 @ hours/day 330 days/year

Additional number of FTLs required.

1. Office entrnace : 1 No. 40 W,
2. Typing table : 1 No. 40 W
3. Gate : 1 No. 40 W
4. Storage tank : 1 No. 40 W
5. Ropeway : 2 Nos. - 40 W each

Total = 6 Nos., 40 W, FTL's required for improving illumination.

APPENDIX - 8/5

REPLACEMENT OF INCANDESCENT LAMPS BY FLUORESCENT LAMP

Sl No	Area	Existing Inc.lamps Watts	# of F.T.L.s to be installed x Watts	Savings Watts #	Annual Energy Saving kWh*	Cost of Implemen-tation Rs.	Annual Cost Savings Rs.
1.	Production office workshop lathe @	1 x 200 1 x 100 2 x 200	6 x 40	400	2112	2400	6970
2.	Water storage tank @	1 x 100	1 x 40	50	264	400	870
3.	Guest house *	1x 100 1x 200 1 x 100	1 x 40 1 x 40 1 x 40	250	1980	1600	6530
4.	Pulverising area *	1 x 200 1 x 200	2 x 40 2 x 40	200	1584	1200	5230
5.	Training centre @	1 x 200	1 x 40	50	264	400	870
	TOTAL				6204	6000	20,470

Choke losses taken into account

Overall payback period = 3 months (@ Rs.3.3/kWh)

* 24 /16 @ hours/day 330 days/year

Additional number of FTLs required.

1. Office entrnace : 1 No. 40 W,
2. Typing table : 1 No. 40 W
3. Gate : 1 No. 40 W
4. Storage tank : 1 No. 40 W
5. Ropeway : 2 Nos. - 40 W each

Total = 6 Nos., 40 W, FTL's required for improving illumination.

APPENDIX - 8/6

REPLACEMENT OF INCANDESCENT LAMPS/FTL's BY COMPACT FLUORESCENT LAMPS

Sl No	Location	Existing Fitting	Proposed CFL	Power Saved W	Annual Energy kWh*	Cost Savings Rs.	Cost of Implementation Rs.
1.	Entrance to main office	2 x 100 W	2 x 15	160	634	2092	800
2.	Maintenance garage	1 x 100 W	2 x 25	160	634	2092	1000
3.	Guest house corridor - Indal house	1 x 100 W	1 x 15 W	80	317	1040	400
	C Type Guest house	1 x 100 W	1 x 15 W	80	317	1040	400
TOTAL					**1902**	**6276**	**2600**

The overall payback is less than ½ year.

* @ 12 hours, 330 days

APPENDIX - 8/7

REPLACEMENT OF INCADESCENT/HPMV LAMPS BY HPSV LAMPS

Sl No	Location	Existing Fitting	Proposed Luminaire SV	Power Saved W	Annual Energy kWh	Cost Savings Rs.	Cost of Implementation Rs.
1.	Power house control panel	1x200 W Incand.	1 x 70 W	130	514	1696	2500
2.	DG Radiator area	1x200 W Incand.	1 X 70 W	130	514	1696	2500
3.	Guest house (D_2LH corner)	1x125MV	1 x 70 W	55	218	718	2500
4.	Pulverising area	1x125MV	1 x 70 W	55	218	718	2500
5.	Crusher - 2	2x125MV	2 x 70 W	110	435	1430	5000
6.	BSP conveyor -2 loading area	1x25 MV	1 X 70 W	55	218	718	2500
7.	Bunker top	2x125MV	2 x 70 W	116	436	1438	5000
8.	Crusher - 2 Conveyor	2x150 W Incand.	2 x 70 W ML Lamp	160	634	2092	5000
9	D1/D3 & D2LH Corner	4x125MV	4 x 70 W	220	871	2875	10000
	TOTAL				**2812**	**9271**	**27,500**

@ 12 hours/day.

The overall payback is 2.9 years.

Additional HPSV lamp fittings proposed for locations which are dark, are given below :

Sl. No.	Details	Type
1.	Main gate security	1 x 70 W SV lamp pole available
2.	Pulveriser storage yard	1 x 125 MV
3.	Area between crusher & Pulveriser	2 x 250 W Halogen
4.	Weight bridge	1 x 70 W SV lamp from building
5.	Crusher - 2 feeding hopper	2 x 250 W halogen

APPENDIX - 12/1

LIST OF SUPPLIERS AND RETROFITS

Eqpt./Retrofit	Manufacturer
Lighting	Beblec (India) Ltd 126, Sipcot complex Hosur 635 126, Tamilnadu
	Electronics India 238/A, 10th Main Road Nagendra Block, BSK II Stage Bangalore 560 050
Capacitors	Asian Electronics Ltd D-11, Road No.28 Wagle Industrial Estate Thane - 400 604
	<u>Marketed by :</u>
	Mysore Sales Intl.Ltd Industrial Products Dvn. MSIL House, 36, Cunningham Road Bangalore 560 052
	Meher Capacitors Pvt Ltd 16(K), Attibele Industrial Area Neralur 562 107 Bangalore District.
	<u>Marketed by :</u>
	Larsen & Toubro Limited P O Box 119, Pune 411 001

Appendix - 12/1 contd..

Eqpt./Retrofit	Manufacturer
	Prabhodan Capacitors Mfg.by Seva Engg.Works Saswadi, Pune
	Crompton Greaves Ltd Dr.E.Moses Road Worli, Bombay 400 018
Energy Efficient Motors	Siemens Limited Jyothi Mahal II Floor St.Marks Road, Bangalore 560 001
	Crompton Greaves Limited Machine I Division Dr. E Moses Road Worli, Bombay 400 018
Variable Speed Drives	Asea Brown Boveri Ltd Sona Towers, 71, Miller Road Bangalore 560 052
	Kirloskar Electric Co Ltd Unit-IV, Belawadi Indl Area Mysore 510 005
	Siemens Limited Jyothi Mahal, III Floor -49 St.Marks Road, Bangalore 560 001
	Allen Bradley Ltd. C-11, Site-4 Industrial Area, Shahibad Pin 201 010

Appendix - 12/1 contd..

Eqpt./Retrofit	Manufacturer
Soft Starters	Jeltron Instruments (I) (P) Ltd 6-3-248/F Road No.1 Banjara Hills Hyderabad 500 034
	Jayshree ElectroDevices (P) Ltd 101, Prabhodhan Apartment 64/9, Erandewane, Pune 411 004
	Bharat Bijilee Ltd Industrial Electronic Division 501-502, Swastik Chambers Chembur, Bombay 400 071
	Control Techniques (I) Ltd 117-B, Developed Plot Industrial Estate Perungudi, Madras 600 096
Timer Control Switch	Larsen & Toubro Limited Post Box No.119 Poona 411 001
Photo Sensitive Switch	Govt. Tool Room Training Centre, Rajajinagar Bangalore 560 044
Flow Meter (Compressed Air)	ITT Barton I Floor, Indra Palace, H block, Cannaught Place New Delhi 110 001

Eqpt./Retrofit	Manufacturer
Compact Fluorescent Lamps	GE-Apar Lighting Maker Chambers 111, I Floor Nariman Point Bombay 400 021
	Crompton Greaves Ltd. Lighting Division Dr E Moses Road Worli Bombay 400 018
Fyrite Kit For CO_2 Measurement in Flue Gases	J N Marshall Pvt Ltd Kasarwadi, Poona 411 034 Maharashtra
Cooling Towers	Paharpur Cooling Towers 81/B, Diamond Harbour Road Calcutta 700 027
	Mihir Engineers Pvt. Ltd. 3rd Floor, Dr D N Road G.P.O. Box No.1389 Bombay 400 011
F R P Blades For Cooling Towers	Parag Enterprises Pvt Ltd [illegible] Tarani Colony, AB Road [illegible]s, [illegible]ya Pradesh 455 001

Appendix - 12/1 contd..

Eqpt./Retrofit	Manufacturer
Power Analyser (To measure kVA, kW, PF, V & A)	Microtek Instruments 40-A, I Main Road I Floor, CIT Nagar Madras 600 035
Lux Meter	Cocin Prakrito Instrumentation 16, Rajendra Nagar P O Mohan Nagar Ghaziabad 201 007
O_2 & CO_2 Analysers	J N Marshall Systems & Services P B No.37, Bombay Pune Road Kasarvadi, Pune 411 005
	Taylor Instrument Co (I) Ltd 14, Mathura Road PO Amarnagar, Faridabad
Star Delta Auto Controllers	Project & Supply A-605, Sunswept, Lokhandwala Complex Swami Samarth Nagar Four Bunglow, Andheri (W) Bombay 400 056
	Technovation Control & Power Systems 5, Savita Sangam Society Near Rajesh Apartment, Gotri Road Baroda 390 007

Appendix -12/1 contd..

Eqpt./Retrofit	Manufacturer
Low Cost Photo Cell Timer	Govt. Tool room Training Centre, Electronic Section, Rajajinagar Indl. Estate, Bangalore 560 044
Voltage Controllers	Beblec (India) Ltd 126, Sipcot Complex Hosur 635 126,
	Electronics India 238/A, 10th Main Road Nagendra Block, BSK II Stage, Bangalore 560 050
Automatic CO_2 Control	Nagadi Energy Systems (P) Ltd 61-C, Muttukada Road Thiruvanmiyur, Madras 600 041
	Contech India P Ltd A/78/9/4, GIDC, Electronic Estate Gandhinagar 382 016
Portable Oil Test Kit	S S Engineering Industries H-35, South Extension, Part-I New Delhi 110 049
Synthetic Flat Belts	NTB International Ltd A-302, Road No.32 Wagle Industrial Estate Thane - 400 604
	Kunal Engineering Co. Ltd Plot No.22, Industrial Estate Ambattur Madras 600 058

Appendix - 12/1 contd..

Eqpt./Retrofit	Manufacturer
FRP Blade Fans for Cooling Towers	Parag Fans & Cooling Systems Ltd Plot No.1/2B & 1B/3A, Indl.Area # 1 A B Road, Dewas 455 001 (M.P.)
Temperature Controller	Sonit Electronics 7, Shivsagar Society Krishnanagar, Near Super Steel Corpn. Safed Pool, Pipe line, Mumbai 400 072
Solar Water Heating Systems	Mantralaya Enterprises 12, Sri Laxmi Nilaya. R.I.E.H.B. Co-operative Society J C Nagar, Mahalaxmipura Bangalore - 560 086
	International Engineering & Trading Co. U-5, Bhagwati Complex Near Mahalaxmi Cross Road Jain Merchant 5 Roads, Paldi Ahmedabad - 380 007
Solar Water Heaters	Prabhu Energy Systems II Floor, Hammed Complex Alake, Mangalore - 575 003 **Factory :** Prabhu Energy Systems 4/96, Naricombu Village Panemangalore - 574 231 Tata BP Solar India Ltd. PI-78, Electronics City Hosur Road Bangalore 562 229

Appendix - 12/1 contd.

Eqpt./Retrofit	Manufacturer
Solar Cooker & Solar Thermal Appliances	Alfa Instrumentation 1267, Teli Mandi, Ist Floor Ambala Cantt. 133 001
Low Watt Loss HRC Fuses	Siemens Ltd. 49, Jyothi Mahal St.Marks Road Bangalore - 560 001
	Larsen & Toubro Limited Bellary Road Bangalore - 560 092
Solar Street Lighting Systems	Tata BP Solar India Ltd. PI-78, Electronics City Hosur Road Bangalore 562 229